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ABSTRACT

Oak Ridge Associated Universities (ORAU) is a private, nonprofit corporation sponsored by 41 colleges and universities in the South. The pioneer among corporate university management groups of its type in the United States, ORAU conducts programs of education, information, research, and human resources development under contract with the U.S. Atomic Energy Commission (AEC) and on behalf of the AEC and other governmental organizations. This annual report includes articles on cooperative university-AEC laboratory relations, professional education, research, public education, training and technology, and budget and organization as related to ORAU. Bibliographical listings are included of the staff, the officers of the corporation, the board of directors, the council of sponsoring institutions, and the chief resident officers. (HS)

25TH ANNUAL REPORT

for the year ending June 30, 1971

OAK RIDGE ASSOCIATED UNIVERSITIES

Oak Ridge Associated Universities (ORAU), Oak Ridge, Tennessee, is a private, nonprofit corporation sponsored by 41 colleges and universities in the South. The Association was chartered in the State of Tennessee in 1946 and operated for its first 20 years as the Oak Ridge Institute of Nuclear Studies. The pioneer among corporate university management groups of its type in the United States, ORAU conducts programs of education, information, research, and human resource development under contract with the U. S. Atomic Energy Commission and on behalf of the AEC and other governmental and private organizations.

MEMBER COLLEGES AND UNIVERSITIES

Auburn University
Catholic University of America
Clemson University
College of William and Mary
Duke University
Emory University
Fisk University
Florida State University
Georgia Institute of Technology
Louisiana State University
Meharry Medical College
Mississippi State University
North Carolina State University
North Texas State University
Rice University
Southern Methodist University
Texas A&M University
Texas Christian University
Texas A&I University
Tulane University
Tuskegee Institute
University of Alabama
University of Arkansas
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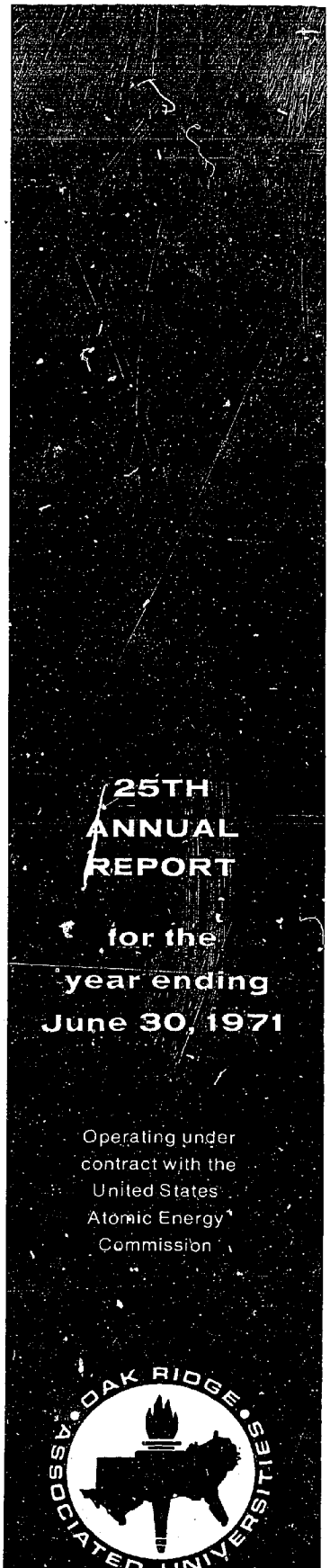
University of Georgia
University of Kentucky
University of Louisville
University of Maryland
University of Miami
University of Mississippi
University of North Carolina
University of Oklahoma
University of Puerto Rico
University of South Carolina
University of Tennessee
University of Texas
University of Virginia
Vanderbilt University
Virginia Commonwealth University
Virginia Polytechnic Institute and State University
West Virginia University


25TH
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Operating under
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United States
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ASSOCIATED UNIVERSITIES

CONTENTS

FOREWORD

The fiscal year covered in this report was one of the most austere in the history of ORAU. Two years ago our level of funding by the Atomic Energy Commission was at six and a quarter million dollars. By this year it had dropped to four and a quarter million. The result has been a period of substantial reductions in staff and considerable belt tightening in all operations. This experience has not, of course, been peculiar to ORAU. Most other organizations like it which are dependent on federal funding for research or education, as well as the majority of our sponsoring institutions, have experienced similar austerity and financial stress. In view of this experience the substantial program accomplishments reported in the following sections are all the more remarkable. In spite of greatly decreased funding and shrinking staff resources it has been a year of real progress and achievement. This is a tribute to the morale and spirit of the ORAU staff and to the extent of their faith in the continuing value and soundness of the organization.

In the nearly two and a half decades since ORAU was formed there has been a proliferation of college and university consortia organized around an increasing variety of specialized interests and purposes. Many institutions find themselves holding membership in several different consortia and new ones emerge each year. In this context, a particularly significant development in the year covered by this report has been the formation of three organizations under ORAU in a new pattern which may have wide application. These are the Southern Regional Demographic Group (SRDG), the University Isotope Separator—Oak Ridge (UNISOR), and the Cooperative Group to Study Tumor Localization of Radiopharmaceuticals. Each of these is described in detail in the body of this report. The significant point to be made here is that each one started with the expectation of incorporating as an independent consortium. The pattern which materialized in each case, however, was one in which the group has its own membership, bylaws, and program under ORAU sponsorship. The affairs of each are managed by an executive committee elected or appointed in accordance with its bylaws. All contributions, grants, or contracts for each group are to or with ORAU. But all disbursements of group funds, employment of personnel by ORAU, and development of new proposals are determined by the executive committee of the group. ORAU provides a secretariat, office space, and financial and administrative services. ORAU also works out all necessary arrangements and approvals with Oak Ridge National Laboratory, the AEC, and other federal agencies.

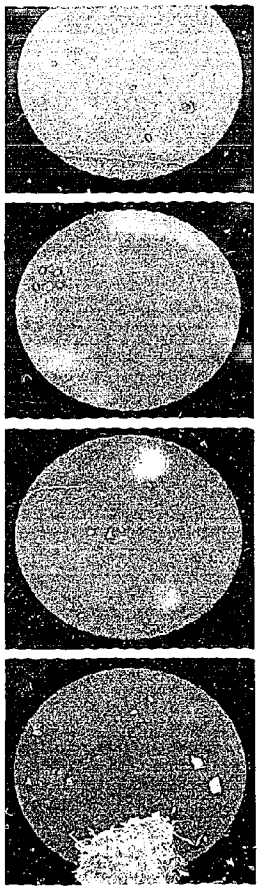
All three groups have so far found this arrangement highly satisfactory from their own standpoints. It has enabled them to get into operation much more rapidly than would have been possible without ORAU services and know-how. Yet each group enjoys the same degree of autonomy in the development of its programs and the achievement of its objectives as it would if independently organized. On the other hand, the interests of the ORAU sponsoring institutions in each group are exercised through the Council and the Board of Directors under a single corporate membership. It would seem that the organizational pattern which has emerged with these three groups could be an attractive one not only for future potential consortia in the ORAU region but for other regions of the country as well.

The publication of this report will mark the completion of the twenty-fifth year of ORAU's corporate existence. The meetings of the Board of Directors and Council scheduled for October 18 and 19, 1971, will mark the beginning of the celebration of our 25th anniversary. Other events in this celebration will follow through the winter and spring of 1972. The theme throughout will be new directions and new challenges for ORAU in the rapidly changing world of the 1970s. In retrospect the year covered by this report may well prove to have been a significant turning point in the history of ORAU—a year in which several traditional missions reached fulfillment and significant new missions began to emerge.

William G. Pollard

WILLIAM G. POLLARD
Executive Director

COOPERATIVE UNIVERSITY-AEC LABORATORY RELATIONS



Cooperative programs between colleges and universities and U.S. Atomic Energy Commission and other government-supported laboratories are a unique and mutually strengthening benefit of the Federal Government's programmatic support of research and development. For the academic community, these programs serve to make available to faculty as well as graduate and undergraduate students the advanced and often unique facilities of large multidisciplinary laboratories for the pursuit of specialized research interests that further both the individual growth of the participants and the overall academic development of their home institutions. For the laboratories, they offer the opportunity for a continuing exchange and infusion of ideas from the larger academic community and, through this process, assistance and support in the achievement of mission objectives and in the necessary evolution of these missions and capabilities in response to national needs.

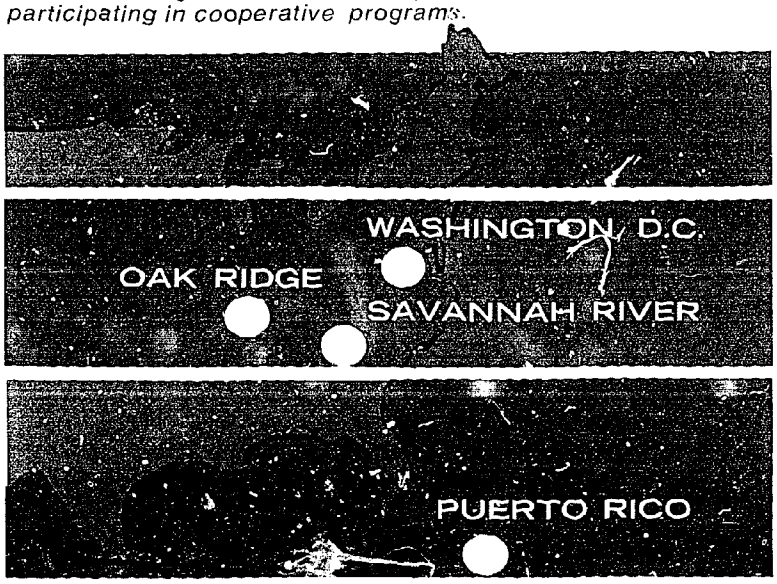
This 25th anniversary year of ORAU and its predecessor organization, the Oak Ridge Institute of Nuclear Studies, represents a significant benchmark, not only in time but in the continuing productive development of these cooperative programs, whose conception and operation was the founding purpose of the Association in 1946. Today they continue as a primary mission of ORAU, broadened and enhanced by new areas of cooperative activity, such as the University Isotope Separator—Oak Ridge and the Southern Regional Demographic Group, themselves the product of the vital interaction between the university community and the national laboratory.

Faculty Research Participation

The Research Participation program provides college and university faculty members with unique facilities and opportunities for research and development at laboratories of the U.S. Atomic Energy Commission and at the National Bureau of Standards. Appointments are available at Oak Ridge National Laboratory, ORAU, Puerto Rico Nuclear Center, Savannah River Laboratory, University of Georgia-Savannah River Ecology Laboratory, University of Tennessee-AEC Agricultural Research Laboratory, and, for the first time in 1970-71, at the Bureau of Standards in Gaithersburg, Maryland.

Faculty members throughout the nation have benefited from the Research Participation program during its 25-year history. Since the first appointment in September 1946, approximately 1,100 faculty from hundreds of colleges and universities in nearly all 50 states, Puerto Rico, and the District of Columbia have participated in this university-government laboratory cooperation. Many departments just beginning research and graduate education in the nuclear sciences have benefited through the use of the exceptional and often unique facilities available at the participating laboratories. Faculty members returning to their campuses have brought knowledge and experience that has enhanced their research and teaching abilities. As a result, the cooperative program has been extremely important to the development of a strong research and development effort in the nuclear energy field.

Nuclear-research facilities at AEC installations in Oak Ridge, Savannah River, and Puerto Rico and at the National Bureau of Standards, in suburban Washington, D.C., are open to faculty members and graduate and undergraduate students participating in cooperative programs.



1970-71 Research Participation Applications and Appointments

ORAU Members		Non-Members	
Applications	Appointments	Applications	Appointments
70	16	194	19

Applications for the limited number of summer appointments have remained consistently high. Approximately 265 applications were received this year, with 37 appointments offered and 35 accepted.

National Bureau of Standards	3
Oak Ridge Associated Universities	4
Oak Ridge National Laboratory	7
Puerto Rico Nuclear Center	2
Savannah River Laboratory	17
University of Tennessee-AEC Agricultural Research Laboratory	2
	35

Faculty appointments are usually made for three-month periods in the summer. However, many participants have been able to extend their stay at the laboratory by combining a three-month appointment with a sabbatical leave, thus providing longer and more productive periods of research and maximizing the benefits of the program. The faculty member is paid an amount equal to his monthly university salary. He also receives an additional allowance for dependents when accompanied by his family.

As an integral part of the Research Participation program, short-term research visits have also been extremely beneficial to on-going research in various university departments. Through this program, 343 visits were made this year to participating laboratories for approximately 1,300 man-days of research. Travel expenses are paid for the visitors and, when possible, cost-sharing arrangements are encouraged. This short-term activity is designed especially to permit the faculty member who has held a Research Participation appointment to keep open the channels of communication between the laboratory and his institution for continued collaboration in research and development.

To obtain information on the value of the short-term visits, all of those holding contracts for this purpose were contacted this year and requested to describe the benefits to themselves and their departments from this collaborative research. The responses emphasized uniformly the professional benefits of this activity and many included extensive bibliographies of papers written from work at the laboratories.

Laboratory Graduate Participation

To emphasize more clearly the objective of the former Oak Ridge Graduate Fellowship program as a cooperative university-AEC laboratory effort, its name was changed during the year to Laboratory Graduate Participation. Under the new title, equal emphasis is given to candidates at the MS and PhD levels who seek appointments for full-time graduate thesis research.

Through more than 20 years of operation, this program has had a history of outstanding success. More than 225 graduate students have received their degrees, 210 at the doctoral level. The remaining number who received the MS is quite small because the program has, until the present change, emphasized predoctoral work almost exclusively.

The program originated in 1950 under the sponsorship of the former Oak Ridge Institute of Nuclear Studies, now ORAU, and Oak Ridge National Laboratory. In 1963, the Savannah River Laboratory and the Puerto Rico Nuclear Center were approved for participation. The University of Georgia-Savannah River Ecology Laboratory became a participant in 1969 and, in 1970, the National Bureau of Standards.

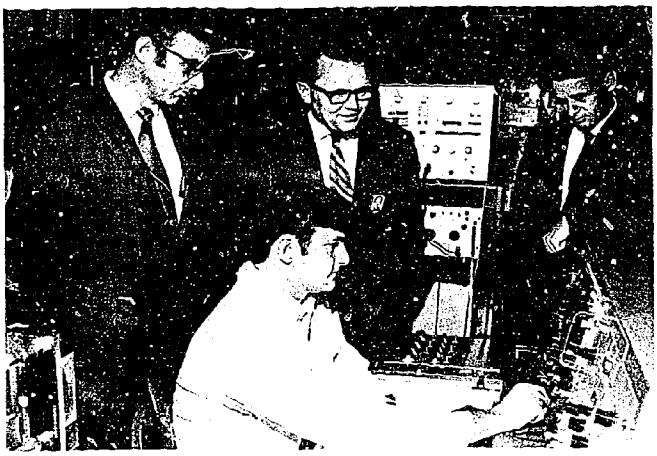
Application is made by the graduate dean on behalf of a qualified student in his institution. In this way, the university certifies that the student is ready to pursue full-time thesis research. Appointments thus serve to expand the research potential of the university and enable students to undertake thesis work for the MS or PhD that would not be possible on their own campuses. The interaction between the participating students and laboratory staff adds greatly to the scientific vitality of both.

The graduate dean appoints a research committee consisting of university faculty and laboratory staff. University members are reimbursed for travel expenses to the laboratory for committee meetings and to discuss on-going research. This provides an avenue for greater university-laboratory involvement which benefits both organizations. With the strong emphasis on environmental problems at many of the participating laboratories, the graduate-participant arrangement provides faculty and students a direct means of involvement in some of the new frontiers of science.

Initial appointments are for six months for master's degree and one year for doctoral-degree candidates; these are renewable up to a maximum of one and two years, respectively. A graduate participant must be enrolled at his university and normally required tuition and fees are paid in his behalf.

1970-71 Laboratory Graduate Participants

Brookhaven National Laboratory	
Theoretical Reactor Physics	1
Oak Ridge National Laboratory	
Analytical Chemistry	2
Biology	5
Chemistry	4
Electronuclear	1
Ecological Sciences	4
Health Physics	8
Instrumentation and Controls	1
Mathematics	3
Physics	3
Reactor Chemistry	1
Solid State	2
Thermonuclear	3
Savannah River Laboratory	
Analytical Chemistry	1
Computer Applications	1
Experimental Physics	2
Savannah River Ecology Laboratory	3
Total	45



Laboratory Graduate Participants at AEC installations work under guidance of a research committee appointed by graduate dean that consists of university faculty and laboratory staff members.

Oak Ridge Resident Graduate Program

Graduate degrees at both the master's and doctoral levels may be earned in Oak Ridge through a cooperative program involving the University of Tennessee, ORAU, and the Nuclear Division, Union Carbide Corporation. The Oak Ridge Resident Graduate Program was established initially in 1946 to provide graduate-level study for Union Carbide scientific and technical staff members whose formal studies had been interrupted by World War II. Today, the program continues to further the professional advancement of Union Carbide, AEC, and ORAU employees.

Graduate-level courses are presently offered in chemistry and physics; mathematics, statistics, and computer science; biology, genetics, radiation biology, ecology, microbiology, and zoology; chemical-, electrical-, mechanical-, environmental and pollution-, and metallurgical engineering; industrial management and economics; foreign languages; and other courses required for the MS and PhD degrees in the nuclear sciences and related fields. Approximately half of the 400 students presently enrolled in the Resident Graduate Program are candidates for the PhD degree. About 25 courses are offered each quarter, scheduled in the late afternoons, evenings, and Saturdays to minimize conflicts with the students' work schedules.

The Resident Graduate Program is operated under a subcontract between the University of Tennessee, Knoxville, and ORAU, and is administered by the UT vice chancellor for graduate studies and research. The program is coordinated with the Knoxville campus through a resident director in Oak Ridge and is supported by Union Carbide for the benefit of its own employees and those of the AEC and ORAU. Classroom, office, and laboratory space for the program are made available by AEC through its contract with ORAU.

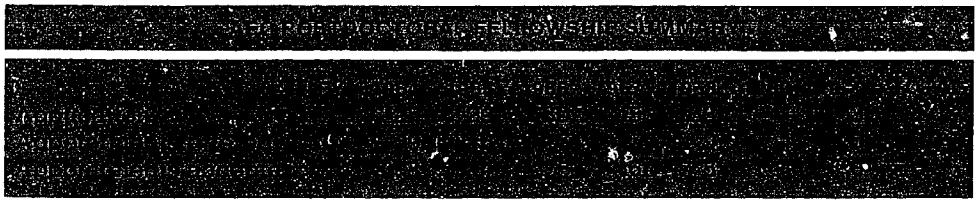
Students who have been admitted to the Graduate School of the University of Tennessee may enroll for academic credit in the Resident Graduate Program. An educational assistance plan, offered by the AEC and its Oak Ridge contractors, reimburses employees for one-half the cost of tuition, fees, and text books upon satisfactory completion of courses. Reimbursement of the remaining one-half is made when an advanced degree has been awarded.

AEC Postdoctoral Fellowships

The Atomic Energy Commission began its Postdoctoral Fellowship program in the summer of 1963. Through its eight-year history, the program provided research opportunities for recent doctoral graduates at Oak Ridge National Laboratory, Savannah River Laboratory, and ORAU, with specific preference given to those planning to enter the teaching profession.

The postdoctoral fellows benefited from association with mature investigators and the use of unique and/or specialized research facilities at these laboratories. Although small in comparison with other national programs, these fellowships provided an opportunity for many scientists to gain experience in nuclear-related fields. The net result was experience for recent PhD graduates, opportunities for renewal and redirection by seasoned scientists, and a contribution to the growth of technical capability in the nuclear field.

Early in 1970-71, the last three fellows in this program completed their appointments. The program was terminated with no new awards during the year.



Undergraduate Research Training

The Undergraduate Research Training program offers college juniors an opportunity to spend 10 weeks during the summer prior to their senior year engaged in independent study and research at a federally supported laboratory. Participants are assigned to established investigators who are regular staff members at the laboratories. Each pursues a problem related to his particular field of interest and opportunities span the physical, biological, and environmental sciences, engineering, and mathematics.

Student responses consistently show that this program has been very valuable in advancing their perceptions of graduate study and career opportunities in their fields of interest. Further, many add that the summer appointment is not only a learning experience from a professional point of view but also a broadening and enlightening look at the people and axiologies of science. In addition to this self-evaluation by the students, their supervisors were also asked to comment on the program. For the first time, each supervisor was sent a questionnaire and the responses were evaluated. Many related that the program had given students a greater maturity and respect for research and the analysis of data, supplementing their academic work with practical experience in a laboratory setting outside the campus environment.

In addition to the summer program, research opportunities are available to students for independent study during the regular academic year. During 1970-71, two students from Furman University, Greenville, South Carolina, participated in the program during the winter quarter, spending two months in research at the Biology Division of Oak Ridge National Laboratory. Also, four students from Emory University in Atlanta spent 10 weeks at the ORNL Ecological Sciences Division during the spring. Efforts to further this type of activity are under way in cooperation with the 4-1-4 Conference, a clearinghouse for new ideas, projects, or programs which will improve the independent study concept or provide new project ideas to its member colleges and universities.

Eighty-six Undergraduate Research Training appointments were made for the summer of 1971 at participating laboratories, which, for the first time this year, included the National Bureau of Standards, as in the faculty program. Of the 86 appointments, 10 were students from ORAU member institutions. Since 1958, there have been 3,501 applications and 869 appointments under this program.

For the fifth consecutive year, ORAU also administered the National Science Foundation-sponsored Undergraduate Research Participation Program in Quantitative Ecology, conducted at the ORNL Ecological Sciences Division. Interest in the program was higher than previous years, with 39 applications received from 16 states and the District of Columbia for the 10 available appointments. The program provides students a stipend plus relocation allowance for a period of 12 weeks during the summer. The primary activity of the program is full-time study with senior investigators on projects involving the movement of radioisotopes and nutrients in the environment, radiation effects on plant and animal populations and communities, computer studies of ecological data, and systems analysis of landscapes and fresh waters.

1970-71 UNDERGRADUATE RESEARCH TRAINING APPOINTMENTS

Oak Ridge National Laboratory	63
ORAU	10
Savannah River Laboratory	10
University of Georgia-Savannah River Ecology Laboratory	1
University of Tennessee-AEC Agricultural Research Laboratory	1
National Bureau of Standards	1
Total	86

Also providing opportunities for student research in the environmental field, two Undergraduate Research Training appointments for the summer of 1971 were made to the new ORNL-NSF Environmental Program. These students worked in the areas of materials management, with special emphasis on toxic materials and their recycling to prevent environmental damage and waste of resources. Their research also introduced them to the problem of energy utilization, expressly the environmental effects of power-plant cooling towers.

Student-faculty visits to the ORAU Special Training Division provide laboratory experience in the nuclear and radiation sciences for advanced science majors and honors students from liberal-arts institutions. Opportunities during two-day to two-weeks visits include lectures and laboratory work in both the physical and life sciences.

Student-Faculty Visits

The ORAU Special Training Division's Student-Faculty Visit program has generated much interest and grown rapidly over the past three years. The program, which began informally with college faculty members (who were familiar with the STD facilities) bringing selected groups of students for a few days of laboratory experimentation, this year involved 40 different student-faculty groups totaling 389 persons. Participants in this program have come principally from small liberal arts colleges whose budgets for purchasing specialized nuclear-science equipment are small. The enthusiasm shown by visiting students and faculty alike for this program underscores the profound need for college science students to gain this type of first-hand experience with the "tools of their trade."

Topics studied by these groups during their two-day to two-week visits vary widely with their individual areas of interest and with the extent of their undergraduate preparation before arrival in Oak Ridge. The program of study, which is developed individually for each group by STD staff members in consultation with the students' instructor, includes such topics as radioactivity, Geiger-Mueller counting of radioactive materials, characteristics and detection of nuclear radiation, gamma-ray spectrometry and spectrum analysis, neutron activation analysis, health physics, applications of computers to radiation studies, and small-accelerator physics.

University Isotope Separator-Oak Ridge (UNISOR)

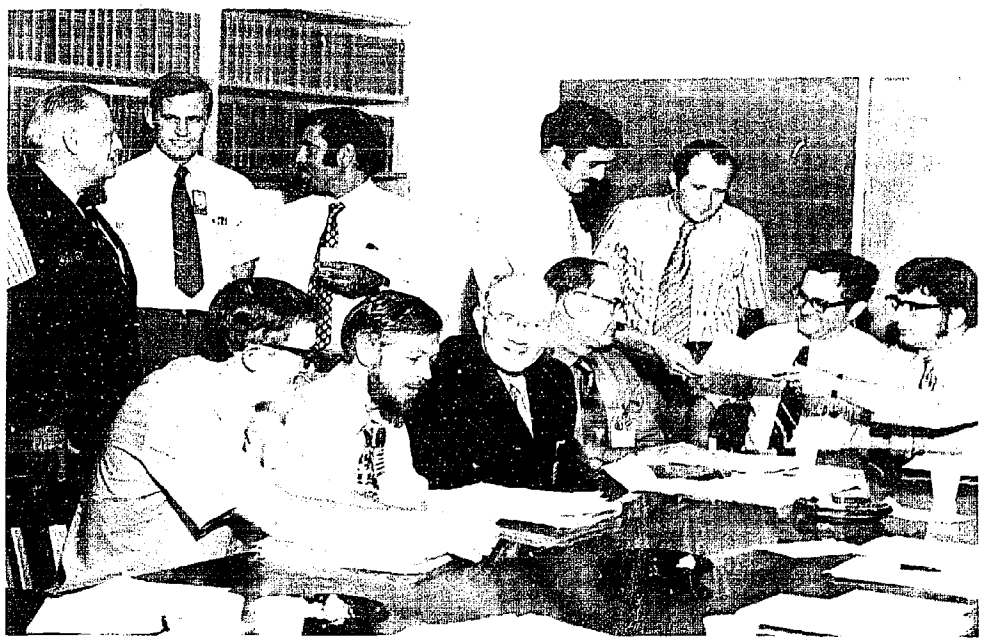
A new program of fundamental research on nuclear structure, using facilities to be developed in association with the Oak Ridge Isochronous Cyclotron (ORIC) at Oak Ridge National Laboratory, was formally organized in July 1970 by ORAU and a group of 11 universities—eight of them ORAU member institutions—in cooperation with the Laboratory. The cooperative venture, to be carried out with joint support from the AEC, ORAU, and the university sponsors, is known as UNISOR (for University Isotope Separator-Oak Ridge). It will involve the addition of an on-line electromagnetic isotope separator to ORIC, a multi-million-volt-range particle accelerator.

The UNISOR project is believed to be unique in that, for the first time, a group of public and private universities and a state government have collectively proposed to buy a major piece of experimental equipment for installation at an AEC national laboratory and then to provide continuing support for its operation over an extended period.

The nine institutions which have made substantial contributions to financial support of UNISOR and were its founding Sponsoring Institutions are: Georgia Institute of Technology, University of Kentucky, Louisiana State University, University of Massachusetts, University of South Carolina, University of Tennessee, Vanderbilt University, Virginia Polytechnic Institute and State University, and ORAU. Subsequently the University of Alabama in Birmingham has also become a Sponsoring Institution. Other institutions which have contributed to UNISOR and are known as Participating Institutions are Emory University, Furman University, and Tennessee Technological University.

Each of the sponsoring institutions will contribute both to the equipping and the annual operation of the UNISOR facility over an initial six-year period. The State of Tennessee, through a special allocation from the State Building Commission to the University of Tennessee, has made a capital contribution of $90,000 toward the purchase of the isotope separator, which is now on order from a firm in Denmark and is scheduled for installation early in 1972. It will be housed, with supporting experimental equipment, in an AEC-provided addition to the present accelerator building at ORNL. Total first-year capital and operating costs are estimated at $650,000, of which the AEC share will be approximately 60 percent, the balance being provided by the university sponsors and ORAU.

Participation in UNISOR will be open to all scientists and engineers with an interest in the construction, development, or scientific use of the new facility, on recommendation from their respective institutions.

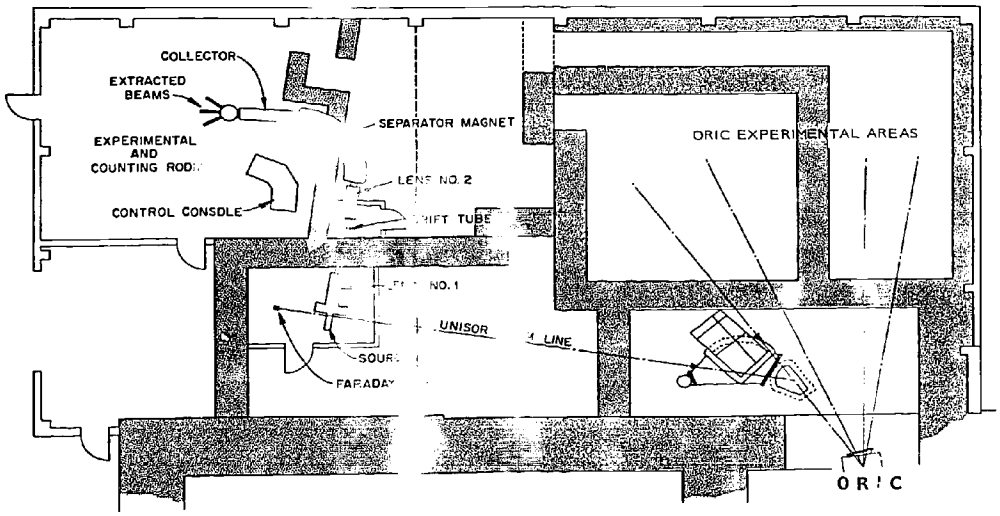


University faculty members have joined with ORAU and Oak Ridge National Laboratory staff in the organization of the University Isotope Separator—Oak Ridge (UNISOR) group. Capital and operating funds for this project to study nuclides far from the line of stability are being provided jointly by the sponsoring institutions, ORAU, and the AEC, through its Division of Research.

Chairman of the UNISOR executive committee is Joseph H. Hamilton, professor of physics at Vanderbilt University. Committee members are: F. T. Avignone, University of South Carolina; W. M. Bugg, University of Tennessee; J. L. Duggan, ORAU; R. W. Fink, Georgia Institute of Technology; K. J. Hofstetter, University of Kentucky; J. A. Jacobs, Virginia Polytechnic Institute and State University; E. L. Robinson, University of Alabama in Birmingham; A. R. Quinton, University of Massachusetts; E. F. Zganjar, Louisiana State University; and one representative of the three Participating Institutions.

UNISOR is designed to afford the sponsoring universities and others that will affiliate with the project either as financial participants or members of its users group an opportunity to explore an important new frontier of nuclear physics and chemistry. This is the study of short-lived nuclei, far from the line of nuclear stability, which hold promise for extending the knowledge of nuclear structure that so far is based largely on the investigation of more stable nuclear configurations. According to the UNISOR proposal: "Less than 25 percent of the nearly 5,000 nuclides theoretically predicted to exist have even reasonably well-known physical properties. From this region of unexplored nuclei, there should be gleaned a rich harvest of new phenomena which will both enlarge and transform present understanding of nuclear structure." With UNISOR, reaction products will be identified by their masses or atomic weights, for detailed investigation of short-lived nuclei on both the neutron-rich and neutron-deficient sides of nuclear stability.

During the past year, ORIC has produced beams of carbon, oxygen, and neon ions accelerated to energies equal or close to 10 million electron volts per nucleon. As a result, addition of the isotope separator is expected to make this one of the best facilities in the United States for research with tailor-made nuclei. Such investigations are closely related to the question of the existence of stable islands of nuclei



An addition to the accelerator building at Oak Ridge National Laboratory, adjacent to the Oak Ridge Isochronous Cyclotron experimental areas, will house UNISOR facility.

beyond the presently known transuranium region. The existence of these superheavy nuclei is presupposed on the basis of theoretical predictions, some of which it will be possible to test with UNISOR.

Among the experiments planned by the universities with UNISOR are: further development of models of the energy-level structure of transitional regions of interest such as the light mass osmium-platinum and rare-earth nuclides; examination of single neutron or proton states in nuclei far from stability for theoretical calculations of nuclear shapes, masses, and properties of superheavy elements; production of new high-spin isomers that may provide important new radioactive isotopes for application in nuclear medicine and industry; improved understanding of how heavy nuclei are generated in stars and the prediction of properties of new elements; detailed study of heavy-particle radioactivity; and determination of the production rate of various nuclear reactions, to give new insight into the structure of the nucleus and mechanisms of heavy-ion reactions.

The combination of isotope separator and heavy-ion cyclotron is particularly well adapted to the requirements of a university-based users group, since a large quantity of data can be taken in a relatively short time. Data reduction and interpretation then will be carried out by the users at their own universities.

Southern Regional Demographic Group

The Southern Regional Demographic Group (SRDG), an organization of university faculty specializing in demography, sociology, economics, and related fields, was established in the fall of 1970 under ORAU auspices to supplement and complement the population research and training programs of universities. It now has a membership of 140 faculty members in the social sciences, principally from universities in the ORAU region.

Members of the group's organizing committee were: Everett S. Lee, *chairman,* a consultant on urban studies at Oak Ridge National Laboratory, who is professor of sociology and principal investigator in the Demographic Training Center of the Social Science Research Institute at the University of Georgia; James S. Brown and George L. Wilber, University of Kentucky; Moye Freymann, University of North Carolina; Charles B. Nam, Florida State University; William W. Pendleton, Jr., Emory University; and Daniel O. Price, University of Texas.

Primary motivation for forming the SRDG was the exceptional resources for demographic research available at Oak Ridge National Laboratory, including extensive electronic-computer facilities and data tapes from the 1970 census.

Under the bylaws adopted by the organizing committee, and accepted and approved by the ORAU Board of Directors as the basis for the Association's sponsorship of the SRDG, the group's purpose will be "to assist in the design of broad regional studies of population trends and changes in the southern region of the U.S. and their social, economic, and environmental determinants and consequences."

"Research and the 1970 Census" was topic of symposium during the first general membership meeting of the Southern Regional Demographic Group, in March 1971, addressed by government and university population specialists.

The SRDG plans to serve "as a structure for the conduct of broad multi-institutional research projects in cooperation with ORNL, as an organized channel of information concerning ORNL programs, facilities, and potential to the academic community in the region, as a means of disseminating information, and generally, to promote population research and training in the southern region."

At the first general membership meeting, held in March 1971 in Oak Ridge, 125 government and university population specialists took part in a conference on "Research and the 1970 Census." The three-day program was supported by a grant from the Center for Population Research of the National Institutes of Health and its proceedings are being published. The program examined major trends in population growth and distribution now emerging from the 1970 census and made plans for further research using the census data.

In addition to its review of the activities of the organizing committee and discussion of the group's future objectives, the SRDG membership, at its March meeting, elected a permanent executive committee, comprising Dr. Lee as chairman, Omer Galle of Vanderbilt University, George Meyers of Duke University, Dr. Pendleton, Dr. Price, and Dr. Wilber. Oak Ridge representatives are James C. Bresee, director of the Civil Defense Research Project at ORNL, under which the Laboratory's program of urban studies is conducted; James L. Liverman, ORNL associate director for biomedical and environmental sciences; and Ralph M. Kniseley, associate chairman of the ORAU Medical Division, who has served as secretary of the SRDG during its formative period. Proposals are now in preparation for support of a central office for the SRDG in Oak Ridge and of specific research projects drawing on the demographic data bank and computer capability available at ORNL.

Developmental Activities with Traditionally Negro Institutions

During the summer of 1970, a second program of workshops for faculty and administrators of traditionally Negro institutions was conducted in Oak Ridge under the title, "Higher Education's Response to the Needs of Society in the '70's." The workshops served to open new lines of development for the academic programs of black institutions, by broadening the acquaintance of participants with the teaching and research resources available to them through governmental and private sources. Moreover, these workshops provided much-needed time for participating faculty and administrators to become acquainted, to exchange ideas, and to identify common problems. Participants themselves defined as an unpredicted result the relationships they developed through the workshops with faculty in other institutions. In a number of cases, they met for the first time and got to know colleagues from institutions in the same state and less than 100 miles from their own campuses.

Two concurrent workshops were held June 8-July 3, 1970, for 33 faculty members, and June 15-19 for 17 administrators. These were followed by two workshops involving 39 faculty, July 6-31, and 40 administrators, July 20-24. A total of 129 faculty and administrators from 67 black colleges in 20 states and the District of Columbia participated in the summer program. (Invitations to the 1970 workshops and the applications received are summarized in Fig. 1) Those attending were from a variety of disciplines in the natural sciences, humanities, and social sciences, with individual interests ranging from physics to philosophy. Natural sciences were represented by 42 participants, social sciences by 21, and the humanities by 16. Among participants in the one-week sessions

for administrators, there were two presidents, one vice president, 16 deans, and 38 other administrators. Fifty-nine workshop speakers presented lectures and/or participated in group discussions. They represented the U. S. Atomic Energy Commission, Department of Health, Education, and Welfare, Oak Ridge National Laboratory, University of Tennessee, ORAU, and other educational and research organizations.

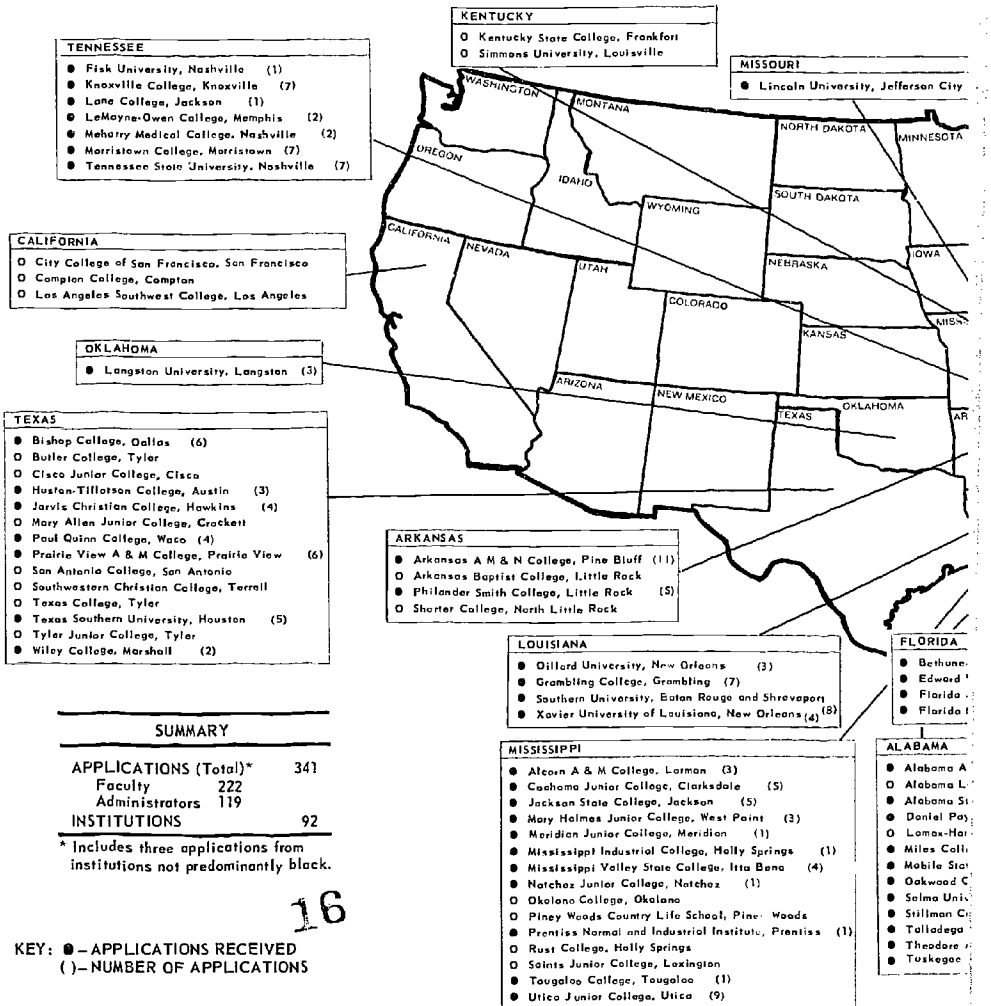
A significant result of the workshops has been the initiative shown by the participants, during and since the Oak Ridge program, in identifying needs, formulating plans, developing projects, and following through on proposals for individual and cooperative action to strengthen their institutions. Programs and projects developed and reported by participants to date have resulted in grant and contract commitments by the Federal Government, principally through the Office of Education, Department of Health, Education, and Welfare, totaling $545,000.

Together, the 1970 workshop and a 1969 session for the six black institutions with engineering programs were carried out at a total cost of less than $150,000. They have resulted in new activities at participating institutions that have brought them new financial assistance in excess of $1.1 million. As a further aid in evaluating the impact of the workshops, participants were reconvened in small groups during the year at different campuses. Three such "miniconferences" were held: October 28-29, 1970, at T. A. Lawson State Junior College, Birmingham, Alabama; November 19-20, 1970, at North Carolina A & T State University, Greensboro; and January 28-29, 1971, at LeMoyne-Owen College, Memphis, Tennessee. These conferences gave an excellent insight into the participants' reactions to their experiences in Oak Ridge and provided a variety of new ideas and suggestions for additional activities.

One result was the establishment of a quarterly newsletter for interinstitutional communication of new ideas and occurrences. The first issue of a "TNI News Bulletin" was mailed in January 1971 to all workshop participants and was well received.

At the conclusion of the series of followup conferences, a representative group of participants was invited to meet as a task force to

Summary of invitations extended and applications received for 1970 Oak Ridge workshops for faculty and administrators of traditionally Negro institutions.

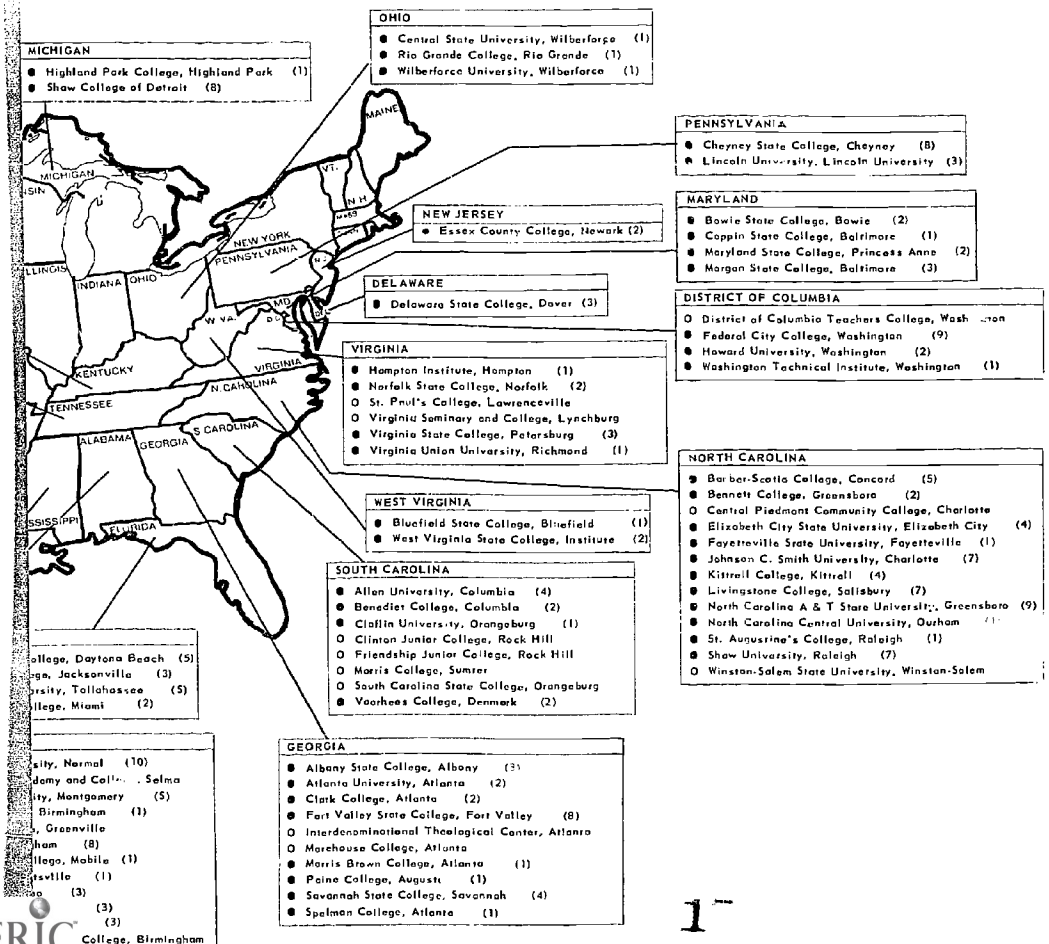


SUMMARY	
APPLICATIONS (Total)*	341
Faculty	222
Administrators	119
INSTITUTIONS	92

* Includes three applications from institutions not predominantly black.

KEY: ● – APPLICATIONS RECEIVED
( ) – NUMBER OF APPLICATIONS

discuss and guide ORAU's future relationships with black institutions. This advisory group, called LINC, is composed of: George Ferguson, Howard University, chairman; Calvin O. Atchison, Tennessee State University; Z. W. Dybczak, Tuskegee Institute; Sister M. Eucharista, Xavier University of New Orleans; W. W. Grigorieff, ORAU; Freddie L. Groomes, Florida A & M University; Joe Hargrove [illegible]ansas A M & N College; Hardy [illegible]ston, Jr., University of Tennessee; [illegible]nes U. Lowe, Meharry Medic[illegible] College; William H. McArthur[illegible] Kno[illegible]le College; Paul E. Parker, North C[illegible]olina A & T State University; Lillie [illegible]. Singleton, T. A. Lawson State [illegible]ior Col[illegible]ge; and Herman B. Smit[illegible] National Association o[illegible] S[illegible]ate Universities and Land-Gr[illegible]nt Colleges.



At year's end, ORAU issued a summary report on its two years of developmental programs carried out with and on behalf of black institutions. This activity began early in 1969 at the initiative of the ORAU Engineering Education Committee.

Engineering Education

The ORAU Engineering Education Committee, which last year was expanded to include representatives of the six traditionally Negro institutions with engineering programs that participated in the 1969 Oak Ridge workshop, met October 4, 1970, in Cleveland, Ohio, on the occasion of the annual meeting of the Engineers' Council for Professional Development. Two areas identified by the committee as of general interest to its activities in the '70s are: (1) recruitment of engineering students, with increased emphasis on joint efforts and (2) greater interaction between black institutions and their predominantly white counterparts.

Members of the committee are: J. J. McKetta, University of Texas, chairman; Karl Brenkert, University of Mississippi; M. Q. Burrell, Southern University; W. J. Carter, Tennessee State University; Z. W. Dybczak, Tuskegee Institute; G. A. Ferguson, Howard University; M. J. Goglia, University System of Georgia; A. E. Greaux, Prairie View A & M College; L. H. Johnson, Tulane University; Hardy Liston, Jr., University of Tennessee; J. W. Morris, Savannah River Laboratory; Lewis Nelson, Oak Ridge National Laboratory; F. N. Peebles, University of Tennessee; L. R. Quarles, University of Virginia; and W. W. Grigorieff, ORAU, secretary.

Savannah River Nuclear Education

The Savannah River Nuclear Education Committee held two

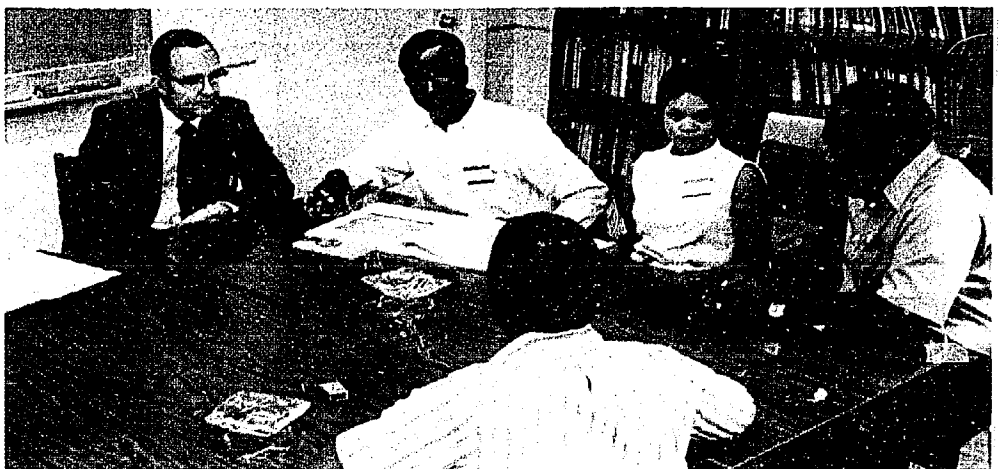
regular meetings, the 16th and 17th since its formation, on January 19, 1971, at the Savannah River Laboratory and on May 19, 1971, at Emory University. The committee continued to provide a forum for discussion and an opportunity for cooperation between the universities, the laboratory, and the U. S. Atomic Energy Commission. A californium-252 study, conducted by the Georgia Institute of Technology on behalf of the committee, was renewed for a second year; the source has been used by students and faculty in many teaching and research applications.

At its May meeting, several possible joint activities in the broad area of environmental sciences were examined. A significant facet of the committee's operation during the year was that the participating institutions provided the financial support. Committee members are: Mark Brown, Medical College of Georgia, chairman; R. W. Henningson, Clemson University; C. H. Ice, Savannah River Laboratory; H. L. Kilburn, AEC Savannah River Operations; J. A. Morris, South Carolina Commission for Higher Education; John M. Palms, Emory University; Carlyle J. Roberts, Georgia Institute of Technology; H. F. Robinson, University System of Georgia; O. F. Schuette, University of South Carolina; Keene M. Wallace, Medical College of South Carolina; Robert M. Wood, University of Georgia; and W. W. Grigorieff, ORAU, secretary.

A total of 129 faculty and administrators from 67 black colleges participated in four workshop sessions in Oak Ridge during the summer of 1970. Daily sessions included formal lecture and panel presentations, followed by small work-group meetings to develop project and program proposals.

Administration and Support

Within ORAU, the Faculty Research Participation, Laboratory Graduate Participation, Postdoctoral Fellowship, and Undergraduate Research Training programs are administered by the University Programs Office, headed by Granvil C. Kyker. The Oak Ridge Resident Graduate Program and Student-Faculty Visits for radioisotope instruction are administered by the Special Training Division under the chairmanship of L. K. Akers. The University Isotope Separator—Oak Ridge (UNISOR) has its secretariat at ORAU and is supported cooperatively by the participating institutions, ORAU from its own corporate funds, and the Atomic Energy Commission's Division of Research, Paul W. McDaniel, director. Initial support for the Southern Regional Demographic Group has also been provided in part from ORAU corporate funds. The developmental activities with Negro colleges and universities, supported both by AEC and U. S. Office of Education funds, and the programs of the Engineering Education and Savannah River Nuclear Education Committees are under W. W. Grigorieff, assistant to the executive director. Except as otherwise noted, the above activities are all part of the program of the AEC's Division of Nuclear Education and Training, whose director is Elliot S. Pierce.



PROFESSIONAL EDUCATION

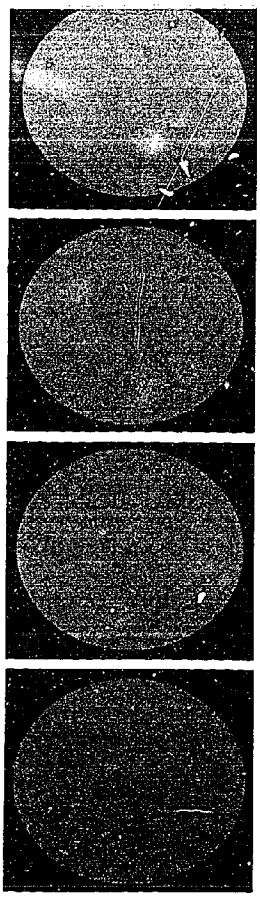
Under its AEC contract, ORAU has a primary responsibility for professional education in nuclear and related fields. The accomplishment of this mission has to date involved the training of nearly 8,000 persons in this country and abroad in radioisotope techniques and their medical and research applications, through short courses and institutes for practicing professionals, technicians, and college and secondary teachers of the natural sciences. It also includes administration of the AEC Special Fellowships for graduate study, whose purpose has been to assure that highly trained manpower is available to support the nation's nuclear-energy development for peacetime purposes.

Radioisotope Courses

The Radioisotopes in Research course was first offered by the Special Training Division in 1948 in response to the needs of university professors and science researchers to better understand the principles of radioactivity and its detection and to become informed of research possibilities provided by the newly available reactor-produced radioisotopes. The course has undergone continuous revision and modernization over the years and was offered during the past year for the 120th and 121st times to more than 50 participants in industrial, governmental, and educational positions.

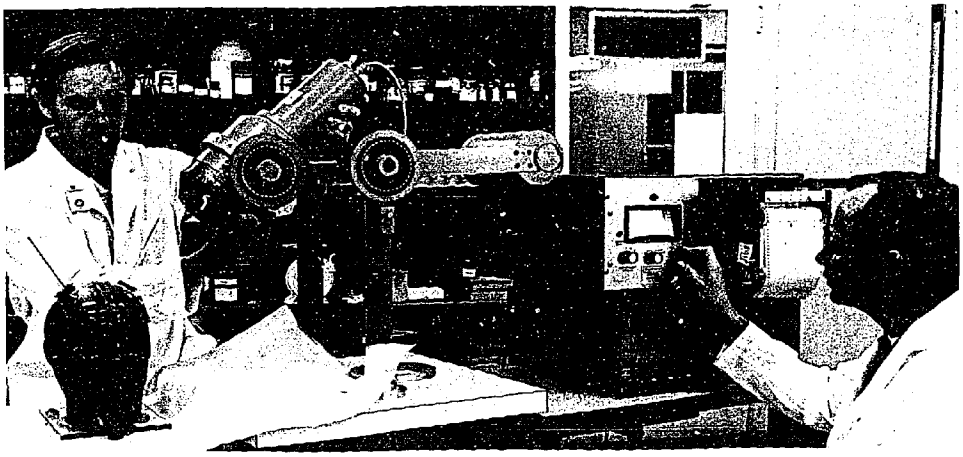
The four-week course in basic radioisotope theory and practice has been used as a model in nuclear education throughout the world. Both the basic course outline and the teaching experiments have been used directly by university and college professors upon returning to their classrooms. The continuing appeal of the course may be attributed largely to the regular addition of modern nuclear techniques and instrumentation. Recent courses, for example, have included scintillation spectrometry using solid state detectors and multichannel pulse height analyzers, neutron activation analysis, and liquid scintillation spectrometry.

Other recent additions to the Division facilities used in the presentation of this course include a nine-terminal time-sharing PDP8/I computer, a 100 microgram and a 4 milligram californium-252 neutron source, and a 700-curie cobalt-60 irradiator. In the near future, a 2 MeV Van de Graaff particle accelerator will be installed to supplement the fast neutron activation, particle scattering, and X-ray experiments now being done on the 150 KeV Cockcroft-Walton accelerator.



Mobile Radioisotope Laboratories

The Special Training Division has taken its Mobile Radioisotope Laboratory program to more than 9,000 persons on 330 small-college campuses since the program began in 1959. During the last year, two of the Division's three van-mounted laboratories—entirely self-contained except for electrical power—visited 15 colleges in six states and provided two-week periods of intensive nuclear education for 85 science faculty members and 103 students.



Medical radioisotope courses offered by the ORAU Special Training Division provide "hands-on" experience for physicians and nuclear medical technologists with state-of-the-art techniques and instrumentation.

The Mobile Radioisotope Laboratory program uses three professional scientists during each two-week visit. A laboratory instructor travels with the unit and two lecturers (specialists from the Special Training Division or from its list of more than 75 consultants in universities across the nation), each visit the campus for one-week periods. Evidence that the program is satisfying a deeply felt need is found in the fact that a large backlog of requests for campus visits remains although no special effort has been made for more than five years to publicize the availability of this program.

This year, in addition to regular mobile laboratory programs, units were made available on loan to four institutions.

Medical Courses

The increasing use of radioactivity in medical diagnostic procedures has created a special need for the training of physicians in the safe use of radioisotopes. Licensure to use radioisotopes for diagnostic purposes requires a basic knowledge of radioactivity measurement techniques and radiochemistry, in addition to clinical experience. Opportunities for such training at medical schools and university hospitals have so far been limited and sporadic. To help meet this need, the Special Training Division offered during the past year two four-week medical qualification courses for a total of 70 physicians. The courses included two weeks of basic nuclear physics and nuclear instrumentation, followed by two weeks of clinical experience using radioisotopes at the ORAU Medical Division hospital.

The Special Training Division also offers a four-week course for nuclear medical technologists to help close the gap between the supply of and demand for qualified personnel in this area. The course was presented twice during the year to 25 participants. Major topics covered in this course include: basic mathematics, nuclear physics and instrumentation, advanced nuclear-medicine instrumentation, radiation chemistry, radiobiology, current clinical uses of radionuclides, and radiation dosimetry and health physics.

These medical courses, as with other division offerings, receive continuing scrutiny to assure that both the content and mode of presentation reflect the state-of-the-art in medical applications of radioisotopes. New laboratory experiments have been developed on nuclide generators, preparation and use of scanning agents, resolution of collimators in scanning, and diagnostic *in vitro* tests. The use of computers in nuclear medicine is a recently added topic. And the clinical portions of both courses now contain material on whole body scanning, linear scanning, color scanning, and the scintillation camera.

Nuclear Science and Engineering Fellowships

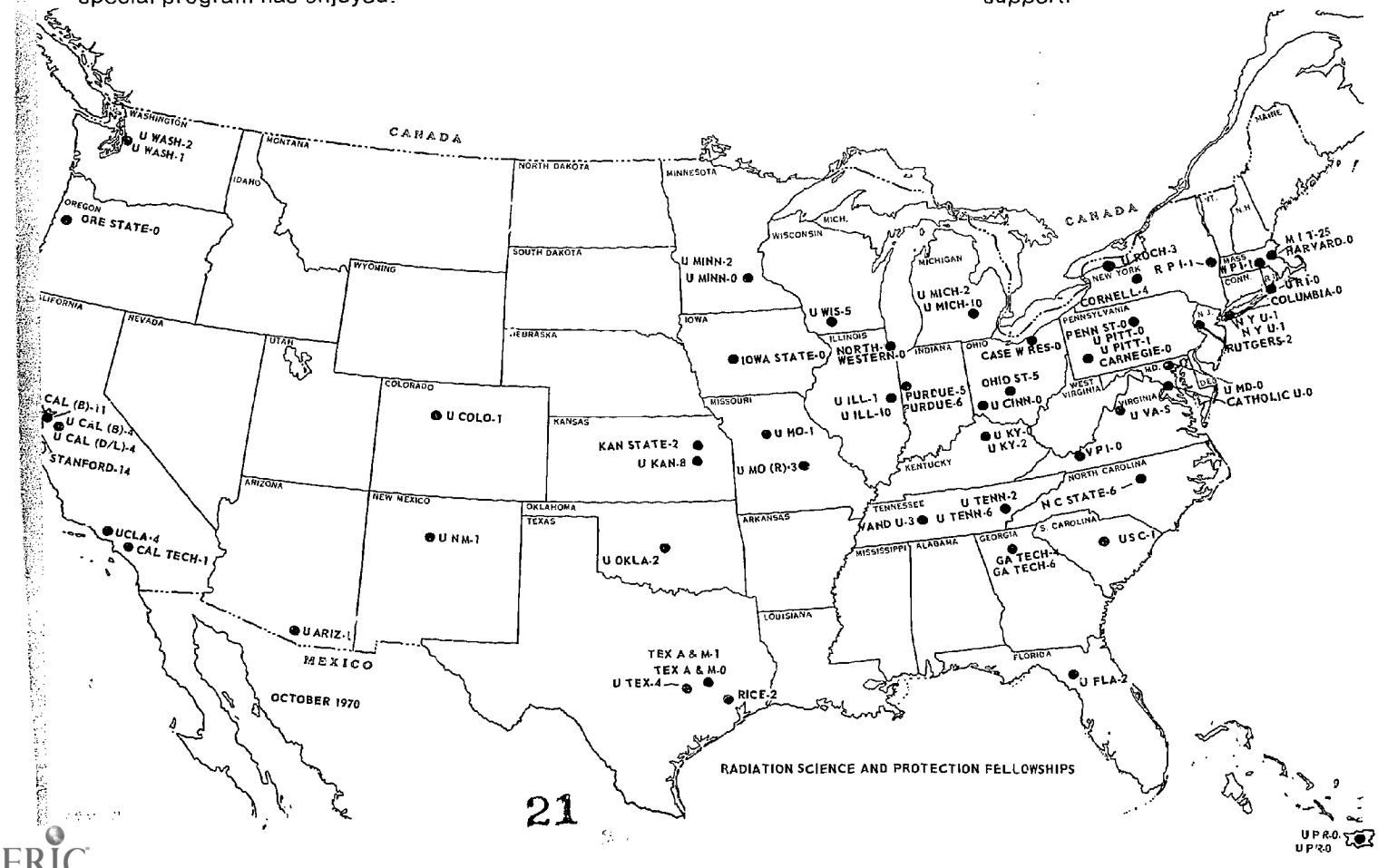
The AEC Special Fellowships in Nuclear Science and Engineering have been the major source of support for graduate training of manpower to serve the needs of rapidly expanding developments in and applications of nuclear energy. With the President's message on the energy crisis and the emphasis placed on developing the Liquid Metal Fast Breeder Reactor, many more highly trained specialists will be needed in the next five years.

Although this program, administered since its inception in 1957 by ORAU, has been small by comparison with other national fellowship programs, its impact on manpower development in the nuclear field has been large. Other major fellowship agencies appoint only a very few fellows (less than 0.1 percent) who are specifically oriented to nuclear fields (and these few are frequently former AEC Special Fellows who have had the maximum of three years of support under this program). Responses from former fellows regularly verify that their career activities are in the mainstream of nuclear science or engineering practice. These observations illustrate the importance and success which this special program has enjoyed.

During the fall of 1970, the decision was announced that this program would be phased out over a three-year period, beginning with no new fellowship appointments for the 1971-72 academic year. Only current fellows are to be eligible for renewal for second-and third-year awards. These fellows were encouraged in October 1970 to apply for other support along with their reapplication for renewal in 1971-72, in the event that even further restrictions should be imposed on this program. The number of fellows supported under the program decreased by seven percent in 1970-71 and appointments available for 1971-72 will drop about 50 percent.

This year, of the 139 fellows in the program at 31 universities, 40 were first-year fellows, 61 second year, and 38 in the third and final year of fellowship support. During the year, 77 reapplications for 1971-72 by current fellows were received and 74 offers were made, with 67 of these fellows accepting the renewals.

1970-71 AEC Special Fellowships in Nuclear Science and Engineering and Radiation Science and Protection were distributed as shown among the participating universities in the two programs. There were 139 NSE and 48 RSP fellows at the first, intermediate, and terminal years of support.



Abstracts of all theses and dissertations are collected from fellows and distributed quarterly to advisers, fellowship board members, and others involved with the program. Of all fellows submitting abstracts, 24 had received doctoral degrees and 14 had received master's degrees during 1970-71. Statistics for the last three years show the following numbers of degrees in nuclear science and engineering earned under the program or within six months after termination of fellowship support:

	Master's Degrees	Doctoral Degrees
1967-68	32	31
1968-69	32	21
1969-70	36	21
Total	100	73

Radiation Science and Protection Fellowships

Radiation Science and Protection is the second area of support for graduate study under the AEC Special Fellowship program. These fellowships are a main factor in recruiting and training specialists in this field for expanding developments and applications in nuclear energy. Appointments are offered to college graduates in the basic sciences and engineering. Selection is based, as with the Nuclear Science and Engineering fellowships, on national competition among qualified applicants.

A basic criterion for the recognition of professional health physicists is certification by the American Board of Health Physics. Professional health physicists trained by way of this fellowship program have excelled on the certification examination. This is strongly supported by the report, "Analysis of the Records of American Board of Health Physics Applicants," by Dade Moeller, Harvard School of Public Health. Eighty-five percent of all Special Fellows taking the exam have been certified, compared to a 64 percent overall rate of success for all of those taking the exam. Thus, fellows who have been trained by this program hold an enviable record of successful participation in the field of their fellowship.

The need for health physicists is expected to continue to grow as nuclear-energy applications expand. Nuclear-power development is increasingly concerned with the environment and the amounts and types of radionuclides released from reactors. State regulatory agencies are actively involved in the setting of radiation limits. The use of radioisotopes in hospitals is now commonplace and very rapidly expanding. These are some of the prominent areas of involvement for professional health physicists who have received graduate training under this program. As these fields continue to expand, it is predicted that more than 200 health physicists trained at the master's level, or with equivalent training by experience, will be needed annually over the next 10 to 20 years.

Radiation Science and Protection appointments are made for a fellowship year of 12 months and are renewable competitively for a maximum of three years. The first fellowship year includes a regular academic year of formal graduate school courses at one of 18 participating universities, with the summer following devoted to applied training in health physics at a major AEC laboratory installation. Intermediate- and terminal-year fellowships support continuation of work toward an advanced degree. Stipends are $2,400, $2,600, and $2,800 for the first, intermediate, and terminal years of fellowship support, respectively. An additional allowance is made for a spouse and for each dependent child and travel to and from AEC laboratory installations is reimbursed. A dislocation allowance is made to first-year fellows during their assigned summer of applied training and an institutional allowance is paid to the fellowship university in lieu of all tuition and fees; any excess in the latter allowance may be used by the institution to enhance its laboratory facilities for graduate training and research in radiation protection.

This year, 73 new applications were received for first, intermediate, and terminal-year awards and each applicant was notified that it was possible, although by no means assured, that funds would be available for new appointments in 1971-72. In late summer, a limited number of new appointments were offered.

Twenty reapplications by first-year fellows for intermediate-year support resulted in 13 offers of renewal appointments, all of which were accepted. Fourteen intermediate-year fellows reapplied for terminal-year support, with nine offers made and eight acceptances. During 1970-71, there were 48 fellows in the program—19, 23, and 6, respectively, at the three levels.

Health Physics Course

Accompanying the AEC's gradual transfer to the states of responsibility for licensing and regulating the users of radiation and radioactive materials is an increased need and responsibility for training state-employed radiation control officers. During the past year, a 10-week course in Health Physics and Radiation Protection was presented for 18 participants (including a few

participants from industrial and governmental sources). The course provides training in the fundamentals of health physics and extensive field practice, including work at the ORNL Health Physics Research Reactor and criticality facility.

Summer Programs for College and University Faculty

During the summer of 1970, the Special Training Division conducted a special one-week seminar on radioisotope applications for six college teachers. This program featured a two-day orientation to advanced nuclear detection instrumentation, followed by three days of special projects of interest to individual participants. Two of the participants of this seminar remained at the Special Training Division for an additional three weeks to carry out advanced experimental work in radiation biology.

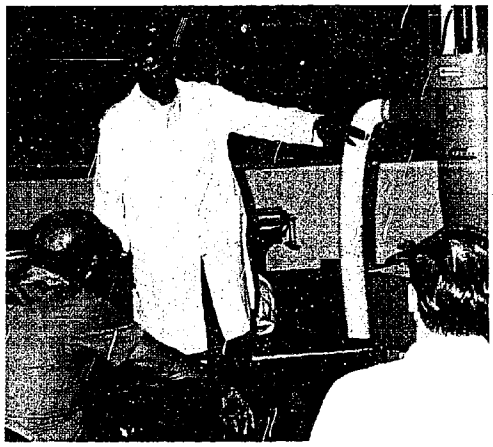
Also during the summer of 1970, 26 participants in Fisk University's academic-year institute spent seven weeks at the Special Training Division for instruction in radioisotope techniques and nuclear science teaching methods. A second such group from Fisk University spent six weeks in Oak Ridge during the spring of 1971. These were the tenth and eleventh groups of academic year institute participants from Fisk University to visit the division.

Environmental Courses

A new two-week course for college and university faculty in Environmental Assessment was introduced during the year and offered for the first time in August 1970 for 23 participants. The two-week course comprised an introduction to analytical techniques for monitoring, measuring, and evaluating both air and water quality. In November, a second two-week program on this topic was presented, with 14 participants in the air quality portion and 26 in water quality. Fifteen more college and university faculty attended one further session on water-quality assessment in April.

In increasing numbers, colleges are operating on a "4-1-4" or "Jan-Plan" schedule which leaves open the month of January for special study by both students and faculty. The resulting demand for stimulating activities for natural-science faculty members led the Special Training Division to design a three-week topical institute on Environmental Aspects of Radiation Sciences for college instructors of biology, chemistry, physics, ecology, oceanography, and the earth sciences.

This new course, attended by 22 faculty members when it was first offered in January 1971, was about equally divided in its lecture and laboratory sessions between 1) study of fundamental concepts of radiation and its detection and 2) specific environmental aspects of nuclear energy and radiation, including nuclear power, nuclear medicine, agricultural and industrial uses of radioisotopes, thermal pollution, ecological problems of radiation contamination, and radioactive waste disposal. A strong positive response by participants in this special institute has stimulated plans for a second such offering in January 1972.



A new ORAU course, Environmental Assessment, offers classroom, laboratory, and field experience with analytical techniques for monitoring, measuring, and evaluating both air and water quality.

Conferences

Two tutorial conferences for women students and community leaders, organized on the theme, "Science, Society, and Our World," were presented in the fall and winter of 1970-71 by ORAU and Tufts University, under a grant from the National Science Foundation.

The two-week sessions for women, in Oak Ridge September 28-October 9, and on the Tufts campus in Medford, Massachusetts, January 11-22, drew 56 participants. They were the 13th and 14th in a series of programs on science for nonscientists begun in 1963 by ORAU. NSF, through its program on public understanding of science, has provided support for this series, which most recently included the three conferences on "Science for Clergymen," conducted during the summers of 1967, 1968, and 1969.

Since women community leaders, often with little current academic training in the sciences, frequently must deal with problems resulting from scientific and technological development, the Oak Ridge and Tufts conferences focused on the interrelationship of science and contemporary society. Special emphasis was given to the impact of science on traditional values.

The programs drew for their technical content on the extensive scientific and engineering resources at the two locations, including Oak Ridge National Laboratory and other U. S. Atomic Energy Commission installations in Oak Ridge and Tufts and other teaching and research institutions in the Greater Boston Area. Included were formal lecture-discussions by leading researchers, workshops, laboratory experiments and demonstrations, round-table discussions, and visits to selected laboratories.

The sharing of computer technology in nuclear medicine and radiation therapy is complicated by the fact that the higher-level languages developed for communication between and among electronic computing systems are difficult to use with the relatively small computers used in nuclear medicine. In response to this widely recognized problem, a two-day symposium was held at the Special Training Division in April 1971, jointly sponsored by ORAU, ORNL, Vanderbilt University, and the Society of Nuclear Medicine. Its purpose was to assess the current needs for and availability of computer technology in nuclear medicine, and to suggest procedures to facilitate the exchange of information and programs between those working in nuclear medicine and computer specialists. The symposium was attended by 48 representatives of organizations involved both in research and clinical studies in nuclear medicine as well as governmental agencies and computer and peripheral-equipment manufacturers. The proceedings of this meeting have been published and are available through the National Technical Information Service under the symposium title, "Sharing of Computer Programs and Technology in Radiation Therapy and Nuclear Medicine."

Administration and Support

Courses and institutes described in this section, as well as the Conference on Sharing of Computer Programs and Technology in Radiation Therapy and Nuclear Medicine, are conducted by the ORAU Special Training Division, under the chairmanship of Lawrence K. Akers. The Atomic Energy Commission Special Fellowship Programs are administered by the head of the University Programs Office, Granvil C. Kyker. The program of science for nonscientists is the responsibility of W. W. Grigorieff, assistant to the executive director. The major portion of the support for these programs is provided by the Division of Nuclear Education and Training of the Atomic Energy Commission, except for the health physics courses, which are supported by the AEC Division of State License Regulations.

Women students and community leaders were participants in ORAU's 13th and 14th programs in a series on science for non-scientists begun in 1963. The two programs were offered in Oak Ridge and at Tufts University, Medford, Massachusetts, on the theme, "Science, Society, and Our World."

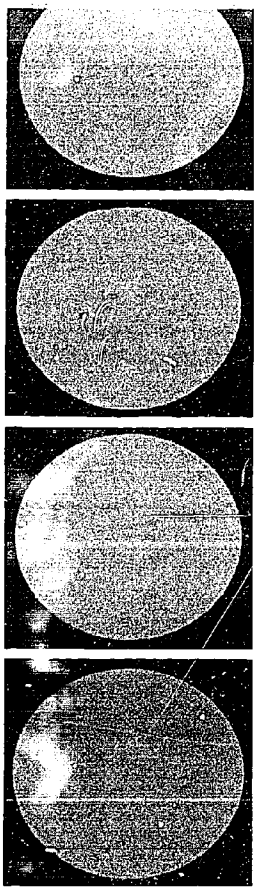
RESEARCH

The Medical Division is the only program unit of ORAU with research as its primary function. Its efforts are principally devoted to the identification of the mechanisms of radiation injury, the improvement of treatment to persons accidentally exposed to radiation, and the development and refinement of methods of using radioisotopes and radiation in the diagnosis and treatment of disease, particularly cancer. The division also pursues basic biological studies related to the ongoing research program. In addition, it plays an important role in educating biomedical personnel at all levels and cooperates with other ORAU divisions in a variety of training activities.

The staff of the Medical Division consists of 20 senior members at the PhD or MD level, 36 research assistants and technicians, and 67 additional employees, including a nursing staff trained to deal with radioactivity and also to function in a research environment. A 22-bed research hospital is devoted entirely to clinical research, and all patients accepted are for investigative programs. The division maintains well-equipped laboratories to support its research; included in the unusual and specialized equipment are total-body irradiators for delivering radiation at a wide range of dose rates, and counting devices to measure a broad range of radioactivity in humans. A variety of small experimental animals are available for experimental use and a special resource is a colony of more than 400 marmosets, small New World primates with great potential for research in immunology.

The program has been set for the 13th Oak Ridge Symposium on Nuclear Medicine, November 15-19, 1971, on the topic, "Clinical Uses of Radionuclides: Critical Comparison with Other Techniques." This year's symposium is to be presented in cooperation with the American College of Physicians as one of the college's postgraduate courses. Published proceedings will be available.

During the past year, with reluctance, training activities were reduced, reflecting the reduction in funds available for this purpose. However, several predoctoral students are at work in the immunology program and two postdoctoral appointments are in effect. The Damon Runyon Fellowship program has provided research opportunities for two visiting staff members. A third visitor working with the division is spending six months of his sabbatical leave from a German university.



As an outgrowth of the wide interest generated by recent work of the division demonstrating the uptake of gallium in a variety of tumors, representatives from a number of institutions organized the Cooperative Group to Study Localization of Radiopharmaceuticals and requested ORAU to sponsor its activities. Its members, predominantly representatives from ORAU member schools, have selected for their initial objective the study of gallium-67 as a tumor-localizing agent. This first effort has the joint support of the National Cancer Institute and the AEC.

The Food and Drug Administration has agreed to support the recently proposed Center for Information on Internal Dosimetry of Radiopharmaceuticals. Its primary function will be to collect, interpret, and correlate information on internal dosimetry of radiopharmaceuticals, using both published sources and data from clinical experiences at ORAU and other medical centers. The FDA will use this material in its evaluation of new radiopharmaceuticals. The radiation dose to the patient must be considered in weighing the risk versus the benefit in the use of a radiopharmaceutical.

Total-Body Irradiation

The total-body irradiation program continues to search for better ways for controlling or palliating leukemias, lymphomas, and related disorders. In this research three different irradiators are currently used: the low-exposure-rate total-body irradiator (LETBI) and the medium-exposure-rate total-body irradiator (METBI), both at ORAU facilities, and the variable dose-rate irradiation facility (VDRIF) at the University of Tennessee-AEC Agricultural Research Laboratory, also in Oak Ridge.

Each of these facilities differs in its radiation characteristics and geometries, resulting in differences in the depth-dose distribution within the patient, which means a difference in the dose to specific organs. Previously, the organ dosimetry for LETBI and METBI has been studied and during the past year these studies were expanded to include the VDRIF.

To simulate the body of a patient, a phantom composed of a tissue-equivalent material is used; within this is molded a natural human skeleton and a set of density-adjusted lungs. The phantom is sliced transversely into sections 2.5 inches thick and each section is drilled with small holes for thermoluminescent dosimeters. The organ volumes can be located in the phantom and the calibrated dosimeters of lithium fluoride are inserted in these sites. When the phantom is reassembled it is exposed in the same manner as a patient. From the dosimeters, the absorbed dose to each of the organs can be determined in "rads."

Such studies aid in determining the amount of radiation delivered to specific organs during therapy or accidental exposure. Also, the information will be applicable to dosimetric and shielding problems during extended space explorations.

At present the effort is focused on a set of clinical trials using single doses of total-body irradiation at two dose rates, to compare the patient's response and degree of palliation when exposures are given at 1.5 R/hr (LETBI) and 1.5 R/min (METBI). The treatments are given to patients with chronic leukemias, polycythemia vera, certain chronic lymphomas (tumors of the lymph system), and selected closely related disorders. Currently these diseases are not regarded as curable, but the patients can benefit from treatment with radiation or with certain chemicals, obtaining relief of symptoms, improved well-being, and ability to lead a more nearly normal life. A

ORAU's largest program unit, and the only one with research as its primary function, is the Medical Division, with a staff of 20 senior members at the MD or PhD level, 36 research assistants and technicians, and 67 other supporting personnel. The division conducts both basic and clinical research in nuclear medicine.

newer aspect of the study is to set up a dosage scheme of protracted low-exposure-rate total-body irradiation, giving the radiation in daily fractions as is customary in conventional beam radiotherapy. The objective is to find an improved way of controlling or palliating these disorders until the day comes when curative treatments become available. Coincidentally, the work will yield a better understanding of man's radiosensitivity, of importance in managing radiation accidents or high levels of radiation that might be encountered in space exploration.

In evaluating the response, the bone marrow and the formed elements of the blood are studied, along with special procedures on blood chromosomes, biochemical tests, and leukokinetic studies.

During the year it was possible to study a radiation accident victim who received an estimated exposure of 260 R gamma total-body irradiation. The patient's laboratory values were followed carefully and he was isolated in the special laminar-air-flow facility to avoid exposure to a possible infection during his period of reduced immunity. He responded to supportive measures and made a satisfactory recovery.

Another aspect of human radiobiology is the systemic response of patients who are receiving radiotherapy or who are exposed to radiation accidentally. The symptoms constitute a syndrome that has been called radiation sickness or, in those involved in radiation accidents, the prodromal syndrome. During the year a retrospective analysis of patients receiving portal radiation therapy was undertaken to determine when in the course of a treatment series the patient will first complain of anorexia, nausea, and vomiting. In a series of 194 patients, anorexia was found to appear earliest, next nausea, and vomiting last. The time of onset for each response depends considerably on whether the patient had any of these symptoms before irradiation. If he did, his chances of having more during the treatment course are very high, and if the treatment time lasts beyond two weeks, the majority of patients will respond. Probability tables for the cumulative onset of these symptoms have been plotted from tabulations that were prepared for actuarial analysis.

A research team continues a retrospective study of radiation-induced hematologic effects in patients. This involves the processing of large quantities of data derived from clinical case histories of patients from many hospitals in the United States and Canada. With the aid of the computer, these data are analyzed statistically and values obtained for the survival of formed elements in the blood after specific and multiple radiation exposures. Interpretations of the results agree with clinical observations that dose protraction aids normal tissue to recover and regenerate more rapidly than pathologic tissue. Differences in white blood cell survival after the same radiation exposure relate more to difference efficiencies in recovery mechanisms than to different cellular radiosensitivities in the diseases studied. An important aspect of this study is the development of improved methods of analyzing clinical data.

A serious complication of sublethal total-body irradiation is infection. Although much information is available on the increased

To house patients with severely impaired resistance to infection as a result of accidental radiation exposure or intensive cancer treatment, a laminar air-flow (LAF) room with this sterile-preparation area is available. The ultraclean facility also provides a special resource for managing patients undergoing bone-marrow transplantation.

susceptibility of laboratory animals irradiated under experimental conditions, there is need for more knowledge on the effects on humoral and cellular defense mechanisms. Also needed are more adequate measures to prevent and treat infections in patients exposed to therapeutic irradiation or those suffering accidental exposure.

To house persons with severely impaired resistance to infections, the Medical Division maintains the laminar air-flow (LAF) room, an ultraclean facility that reduces the exposure of the patient to external microorganisms. It also permits monitoring of the patient's microflora to determine shifts in antibiotic resistance and potential overgrowth or increase of certain component bacteria. All foods, medications, and other materials are sterilized or effectively excluded by sterile coverings. Before the patient enters, the room is sterilized by fogging with an antiseptic solution.

This facility was part of the marrow-transplant protocol referred to in a later section of this report. During the patient's stay in this isolated environment he was given prophylactic non-absorbable antibiotics to reduce the microbial load in the intestine. He had no major or minor infection while in the unit, and his microflora were well controlled, with the possible exception of *Pseudomonas aeruginosa*, which did not become a threat to him.

During the year, efforts continued to characterize the bacterial flora of irradiated patients who receive doses of 100 R, 150 R, or 250 R. These patients are not housed in the ultraclean facility since the degree of radiation depression of their immune system is not life threatening.

LETBI patients receive 1.5 R per hour radiation dose while living for up to nine days in this room within a room, whose interior resembles a motel suite. Radiation field is balanced so that variation in exposure from one part of room to another is no more than 10 percent.

Microorganisms presumably exogenous (not from the patient's own normal flora) seem to become established in the upper respiratory tract and intestinal tract more easily after irradiation. There is also an increased incidence in the number and diversity of transient microorganisms from the respiratory tract, intestinal tract, and urine, suggesting that the patient's ability to maintain a stable microflora has been impaired. These shifts in flora do not represent bacterial infections with clinical symptoms.

Concomitantly, the sera of patients are being examined for antibodies to determine whether the levels are affected by total-body irradiation. Although not constant, decreases in serum immunoglobulins and complement are often seen after irradiation.

Cytogenetics

Although abnormal chromosomes have been observed in connection with many malignant tumors, a clear relationship between the two is not yet defined. Cytogenetic observations suggest a correlation between chromosomal aberrations and malignancy. It has not been determined whether the abnormalities result from the disease process or are significant in its development. In clinically normal persons many agents external to the body such as viruses, chemicals, and radiation can cause breaks in chromosomes. Also, it has been observed in normal controls that the number of abnormal chromosomes in lymphocytes fluctuates greatly. In some instances a high rate of broken

chromosomes follows illness and at other times no apparent correlation exists between a high percentage of damaged chromosomes and recent exposure to chromosome-breaking agents. This variation suggests that chromosome breakages may be a normal defense response.

The cytogenetics group is striving to clarify some of these observations, with particular emphasis on malignancy-related aberrations. The aims are to shed light on how chromosome abnormalities are induced and to determine the mechanisms of removal of abnormal forms and the possible clinical implications of increased numbers of abnormal metaphases.

A continuing study is being made of chromosome breakages in women taking oral contraceptives. The cumulative data indicate that these drugs do cause a small but distinct increase in chromosomal abnormalities in lymphocytes. Interestingly, abnormal chromosomes in control subjects vary according to the season, and the difference in the breakage frequencies between the control and the study group in different months is quite variable. This finding emphasizes the importance of long-range studies in projects of this nature. The effects of the medication may be overshadowed by the effects of other variables in the environment.

This group also took part in the marrow transplant protocol mentioned earlier. Cytogenetic studies were performed on two uncultured ("direct") marrow preparations obtained before the transplant. A chromosomally abnormal "marker" stem-line comprised about 80 percent of the metaphases. Within 8 days after total-body irradiation and infusion of donor marrow, normal diploid metaphases had replaced the aneuploid stem-line. It is probable that these normal cells were engrafted donor cells.

Radiation Immunology and Transplantation Research

The immunology program has evolved from the objective of obtaining therapeutic marrow transplants, particularly as a means of sustaining persons who have been heavily irradiated. For some time work has progressed on determining the effects of total-body irradiation on the immune system of animals. It has been found in animal experiments that fairly high dose rates (50-100 R/min) improve the number of successful transplants. However, the human, much larger than the usual laboratory animal, must be placed at some distance from the radiation source to provide a uniform field of exposure, thus greatly lowering the dose rate. In animals it was found that the degree of the suppression of the immune system was strikingly dependent upon dose rates.

Attempts to follow high-dose irradiation with marrow transplants in treating patients with leukemia began almost 15 years ago. Now, with increased knowledge of tissue compatibility and advances in tissue typing and immunosuppression, interest in achieving transplants has been revived. An adult patient with acute leukemia was given a successful allogeneic graft of marrow from his brother who was found to be a good histocompatibility match. To inhibit the patient's ability to reject the foreign tissue he was given antilymphocyte globulin and was exposed to 500 R of total-body irradiation in the University of Tennessee-AEC Variable Dose-Rate Irradiation Facility (VDRIF) at a high dose rate (40 R/min). Isolated in an ultraclean environment to prevent contact with infectious organisms, he responded with a remission of the leukemia. All newly made red cells were found to be the type of the donor and the platelets and white cells regenerated promptly. When the patient died some months later from the complications of preexisting coronary artery heart disease and opportunistic infections from unusual pathogens, there was no evidence of recurring leukemia, rejection of the graft, or graft-versus-host disease. The suppressions of the immune system, necessary to allow the graft to become established, had also reduced the patient's resistance to infection.

An important adjunct of the Medical Division immunology program is the research colony of marmosets, New World primates that uniquely have a high frequency of fraternal twinning. Because of its unusual reproductive physiology, the marmoset is a chimera produced by nature. It has been shown that there is a complete immunologic tolerance of skin grafts between fraternal co-twins.

In kidney transplant studies continued this year, additional information was obtained on the rejection of kidney grafts exchanged between unrelated marmosets. Although three chimera co-twin animals died within the first postoperative week, the kidney malfunction which occurred apparently was not due to immunologic factors. Past observations lead to the belief that immunologic tolerance extends to this organ among chimeric co-twins; however, this assumption is not conclusive.

One important objective in the study of natural chimerism of marmosets was reached during the year. A red cell antigen suitable for demonstrating erythrocyte chimerism has been defined. This was achieved through use of an isoimmune reagent developed in one of the subspecies. It is a genotypic marker, inherited as a simple Mendelian dominant factor. It was desired to explore the possibility of inducing cell chimerism and tolerance to a third "set" of antigens and also to evaluate the susceptibility of young marmosets to graft-versus-host reaction. In an experiment where neonates were injected with spleen cells from another subspecies, no adverse effect was detected, but in another the results, which included a mortality and runting, were clouded by a blood protozoal infestation from the donor. The attempts to show induction of tolerance to date have been essentially negative but no sensitization by foreign spleen cells has occurred.

During the past year, studies have also been made of the *in vitro* growth potential of blood-forming cells of the marmoset. Surprisingly, it was found that they could be easily cultivated for extended periods, far beyond the anticipated 2 or 3 weeks. Cultivation of mixed yet immunologically compatible blood elements from a natural chimera are a potentially valuable tool for research in immunologic tolerance.

The basic immunology work continues with experiments in mice to understand antigen-antibody reactions as related to transplanting cells, and also the nature of the host-graft relationship in laboratory chimeras.

The dose-rate effect in lethally radiated mice has been pursued further. In work this year, preliminary results suggest that xenogeneic marrow given 24 hours after irradiation is more likely to result in a marrow graft than if given at 2 hours, regardless of dose rate, and that the higher dose rate, regardless of time of marrow injection (2 hours versus 24 hours), gives more permanent and therapeutic grafts. Animal work has also continued on sublethal radiation and antilymphocyte serum (ALS) as a means of suppressing an animal's immune system so that it can accept a foreign tissue graft. With ALS, permanent grafts have been achieved after as little as 600 R total-body irradiation, but the mice experience a graft-vs-host mediated secondary disease.

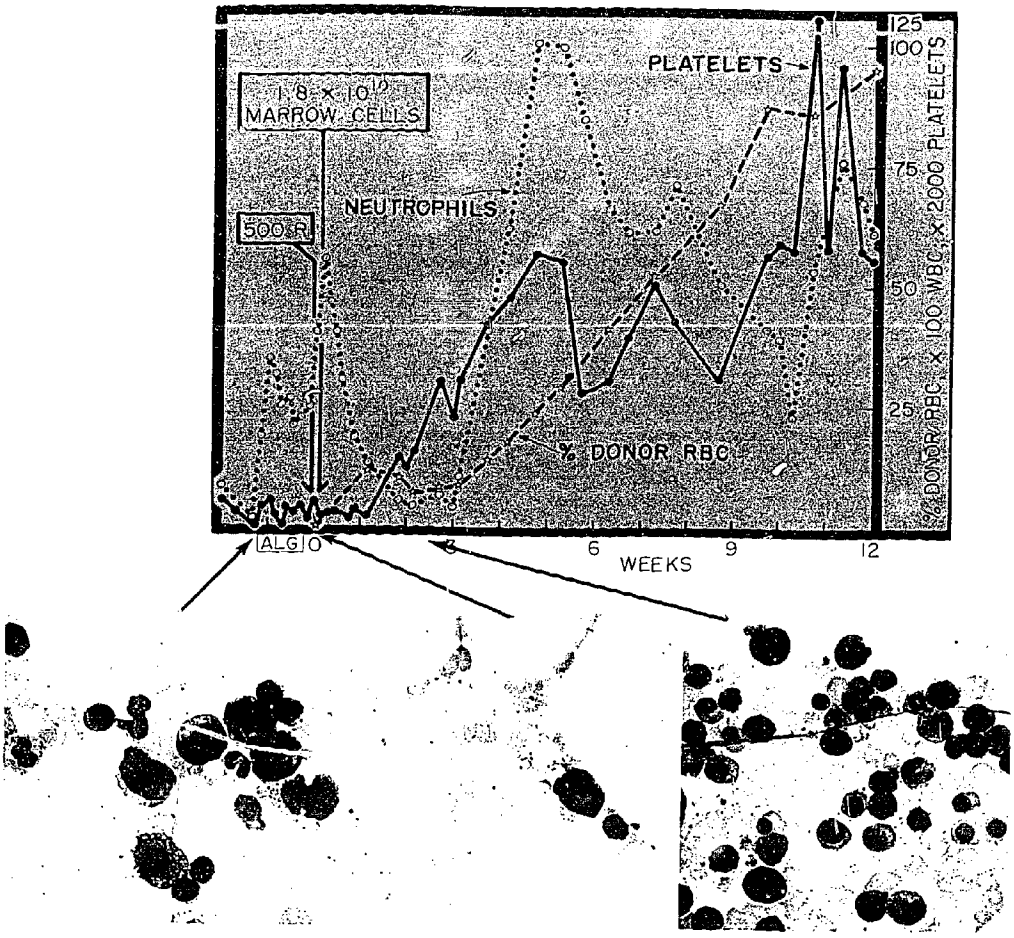


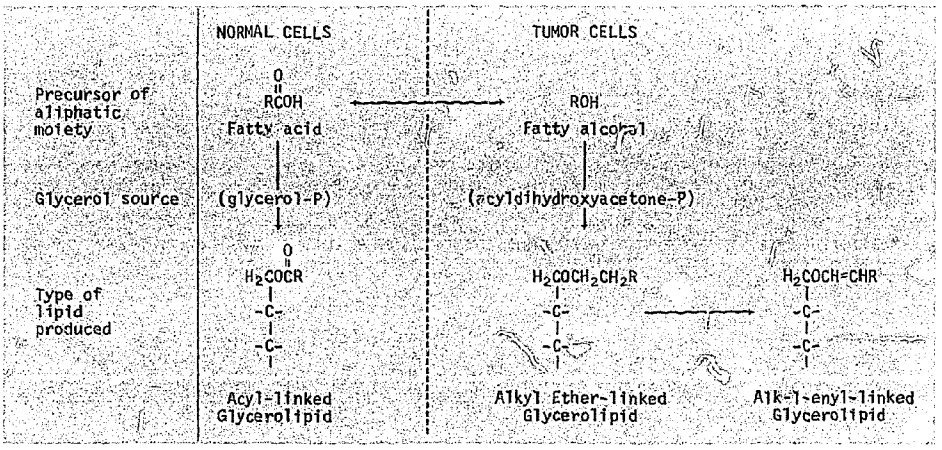
Diagram and photographs provide hematologic evidence of a successful bone-marrow graft in a leukemic patient treated at the Medical Division. After immunosuppression with 500 R of total-body irradiation at a rate of 40 R per minute and a course of antilymphocyte globulin (ALG), the patient was infused with his brother's bone marrow.

Electron Microscopy

The electron microscopy team is an important resource that serves the various research groups of the Medical Division. Primarily it conducts work in the cell biology of the reticuloendothelial and hemopoietic tissue associated with virus infection, malignant transformation, and immunologic responses. One of its important contributions has been to the gallium research of the division.

Microscopic autoradiograms of the thymus of mice showed a pronounced concentration of gallium-67 in phagocytic cells, which are more common in the thymus of leukemic mice than in normal mice. Whether there is also a greater uptake of the radioisotope in leukemic than in nonleukemic thymocytes is not clear. It is known that gallium-67 localizes in a variety of both human and experimental animal neoplasms. Increased knowledge of the mechanism of its localization in these tumors may be an indication of subcellular similarities among various types of malignancies. On the subcellular level, the radionuclide is associated with electron-dense bodies morphologically similar to lysosomes.

In continuing studies of the ultrastructure of lymphatic tissues, lanthanum (which is electron-dense) has been found to be useful as a marker to distinguish between extracellular dense material and dark reticular fibers of the germinal centers. The lanthanum deposition in narrow intercellular spaces of splenic germinal centers and between the larger germinal center cells has confirmed the extracellular nature of the material, distinguishing it from cell processes of the dark reticular cells.



Biosynthesis of three main types of glycerolipids: normal versus tumor cells.

Biochemistry

The biochemistry program is primarily concerned with chemical and metabolic characteristics of neoplastic and normal cells, the biochemistry of ether-linked lipids, and the metabolism of cell membranes. Under active investigation is the function in essential life processes of fats containing ether bonds. Related research is focused on the biochemistry of fatty substances in membranes and subunits of cancer cells and irradiated cells, especially as they relate to radiosensitivity.

In cancer cells a peculiar type of fat accumulates during tumor development. This change occurs in complex lipid molecules of cancer cells. An ether bond is formed between a relatively simple fatty component (long chain fatty alcohols) and a nonfatty substance (dihydroxyacetone phosphate) derived from the metabolic breakdown of sugars. The chemistry and biochemistry of *ether* bonds differ remarkably from the more common *ester* bond that is found in all animal fats. Fatty substances possessing ether bonds are not only an important component of cancer cells but also they have been thought to possess radioprotective and growth-stimulating properties. The manner in which the ether bond is formed in these fatty substances is a newly detected biochemical reaction established by this group. Its findings were accomplished by using compounds labeled with radioactive hydrogen or carbon to trace metabolic reactions in preparations obtained from tumors. The results of these experiments are basic to the understanding of cancer and in the future may prove to be relevant to the broader aspects of cancer therapy.

A noteworthy achievement during the year was the biosynthesis of *O*-alkyl and *O*-alk-l-enyl glycerolipids through enzymic studies. The specific sequence of the steps in forming the *O*-alkyl glycerolipid was established. In collaboration with colleagues at the University of North Carolina, proof was found for the identity of ketone intermediates. Among its numerous experiments, the group also described a cell-free system that synthesizes plasmalogens.

Clinical Investigations in Nuclear Medicine

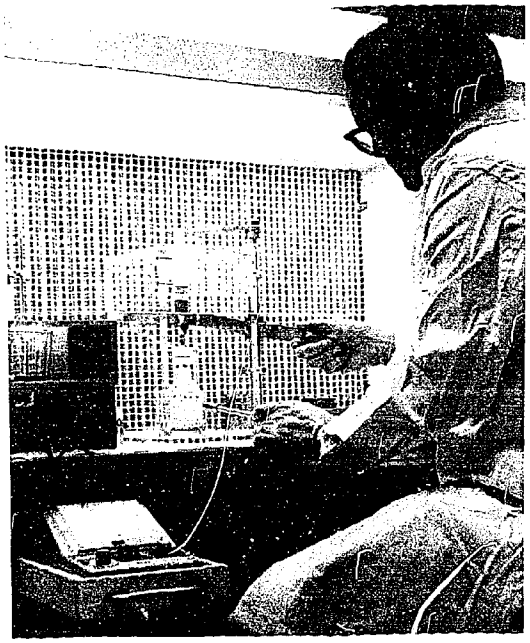
In human studies, experience has been extended to the administration of intravenous doses of gallium-67 to more than 125 patients with a variety of tumors. It has been found that gallium does not localize in malignant tissue in general, but rather in tumors of specific cellular types. The concentration varies from one type of tumor to another as well as from site to site in a given patient. Further, with the same histologic type of tumor, the concentration of gallium may be quite different from one patient to another. The size of the tumor is also relevant; small tumors may escape detection because of the low absolute amount of activity present. This is especially true if the tumor is deeply located and not precisely in the focal plane of the detector. Patients with positive scans have reverted to negative after chemotherapy or radiation. This suggests the possible clinical use of gallium in assessing the effectiveness of therapy.

Experimenting first on dogs, the intralymphatic injection of gallium has also been studied. Later this mode of administration was applied to four patients. The results suggested that there is no advantage in injecting the nuclide by this route, even to demonstrate tumors along the draining lymphatic vessels.

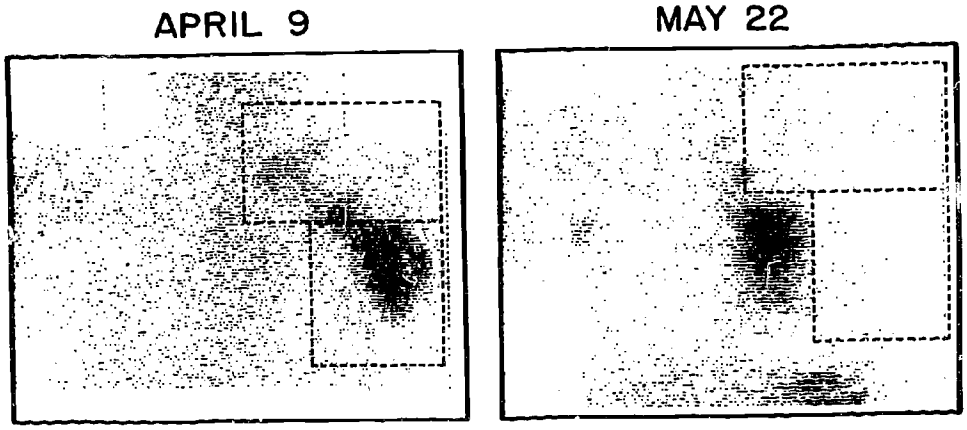
To obtain data for radiation dosimetry, the distribution of gallium has been studied in human tissues at autopsy. Data are analyzed according to time after dose, age, sex, nutritional state, location of tumor, presence of inflammation, and the amount of stable gallium carrier. Among the various normal tissues, the six with the highest values are the spleen, kidney, cortex, adrenal, marrow, and liver. Significant variations exist from patient to patient and, possibly most important, from sites within a given organ. This means that the irradiation received is high focally and not homogeneously distributed among the cells of an organ.

Gallium Study Group

At the time of its organization last year, the Cooperative Group to Study Localization of Radiopharmaceuticals requested that ORAU sponsor the group and serve as its secretariat. Preliminary



Chemist at laminar air-flow laboratory bench carries out sterile preparation of radioactive gallium-67 for intravenous administration in patient with suspected cancer.



Use of gallium-67 in managing treatment of cancer is exemplified by before (left) and after chest scans of patient with reticulum-cell sarcoma. Radiation teletherapy within the outlined areas has achieved control of disease at two sites, but progression outside the radiation field indicates that further treatment is required.

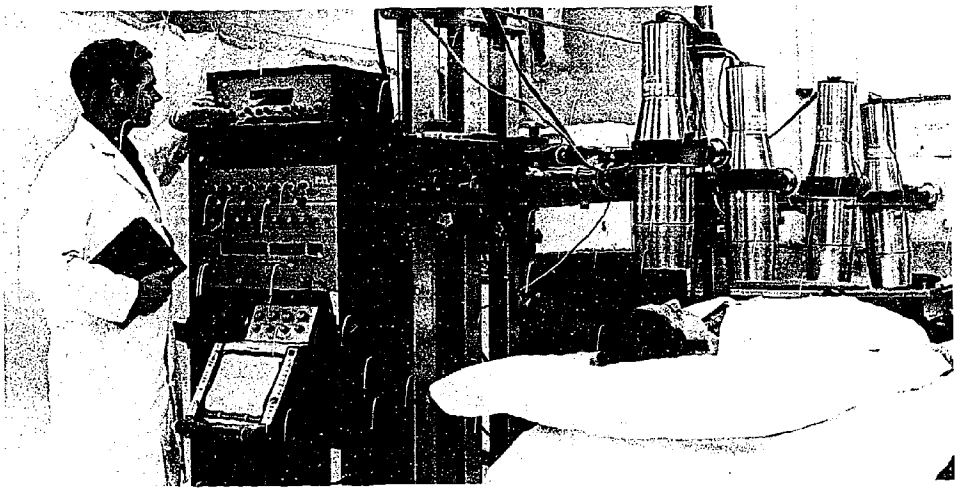
protocols were outlined and a proposal prepared seeking support from the American Cancer Society. Negotiations were also undertaken with the National Cancer Institute and the AEC to support a project to study gallium in lymphoma and lung cancer. The immediate objectives of the latter project are to answer questions about the value of this agent for detecting and staging tumors, determining the effectiveness of treatment, and, later, assessing the need for further treatment. These diseases were chosen because renewed hope to cure Hodgkin's disease has emerged as the result of new radiotherapy and chemotherapy protocols that require exact methods of assessing the extent of the disease. In cancer of the lung, there is a continued rise in incidence coupled with low cure rates and low operability rates because of late detection. Gallium scanning offers a possible hope for earlier detection. The cooperative study will provide a broad data base for standardizing methods of evaluating a new agent. In the lymphoma and lung cancer project, 13 institutions are presently participating, the majority from ORAU member institutions.

Medical Instrumentation and Computer Developments

Constantly serving one group or another within the Medical Division, the instrumentation and computer staffs are indispensable components of the total research team. They recently have linked a new four-probe counter by electronic interface equipment that transmits data to the IBM-1800 computer.

Through this interface, the system can rapidly perform and analyze many dynamic function studies on patients where external monitoring of data from several sites is required. Additional studies will now be convenient, with continuous counts received from the detectors placed over four organs (e.g., heart, liver, spleen, and bone marrow). These counts acquired from a specific organ will help to define the kinetics for certain radionuclides as they are distributed and redistributed throughout the body.

Before a clinical experiment, the four crystal probes are first equalized for counting rate and positioned in predetermined sites over the patient. The physician requests program time from the computer; the isotope is injected into the patient and, simultaneously, computer operation is initiated. Signals from the computer are transmitted back to the experiment site, where they are graphed by a four-pen recorder. The physician thereby can watch progress and make adjustments as required. The computer stores all counting rates received. When the procedure is completed, it automatically generates the required counting profiles and can be programmed for analysis of results. The four-probe counter is now in operation and producing clinical information. The division's computer capability has also been expanded through the creation of new programs for processing, storing, retrieving, and automatically graphing clinical data in a number of projects. Work has proceeded in areas such as physiologic monitoring during radiation, liquid scintillation sample counting, imaging with the scintillation camera, and whole-body counting.



Medical Division computer capability has been expanded to provide electronic interfaces with many sources of clinical data. This year, a new four-probe radiation counter was linked to the IBM-1800, for rapid analysis of dynamic function studies involving continuous monitoring of counts from four organs (e.g., heart, liver, spleen, and bone marrow) to determine how radionuclides are distributed and redistributed throughout the body.

Low-Energy Nuclear Physics

Although its primary mission is training rather than research, the Special Training Division has, for several years, conducted studies in low-energy nuclear physics in association with its developmental work on teaching applications of low-energy accelerators. Much of this work is done in collaboration with university professors. Among the recent participants in this research have been: R. F. Carlton, Middle Tennessee State University; Jung Lin, Tennessee Technological University; H. K. Carter, Furman University; D. L. Humphrey, Western Kentucky University; R. W. Lide, University of Tennessee; and J. D. Spaulding, Pacific Union College.

Recent work has investigated the following nuclear reactions:

1. **The $^{10}B(d, p)^{11}B$ and $^{10}B(d, \alpha)^{8}Be$ Reactions**
   Angular distributions were measured and assignments of Q values were made for the interactions.

2. **The $^{9}Be(d, t)^{8}Be$, $^{9}Be(d, p)^{10}Be$, and $^{9}Be(d, \alpha)^{7}Li$ Reactions**
   The $^{9}Be(d, t)^{8}Be$ reaction was fitted with a series of Legendre polynomials of the form:

$$\frac{d\Sigma}{d\Omega} = \frac{20.9\,(1 - .31P_1 - .40P_2 + 13P_3)}{4\pi}$$

   The other reactions were described in terms of a plane wave stripping mechanism of the form:

$$\frac{d\Sigma}{d\Omega} = K\left|J_Z(kr)\right|^2$$

3. **The $D(^{3}He, p)^{4}He$ Reaction**
   The resonance in the reaction cross section yield curve was measured and the high energy protons were used for $\frac{dE}{dx}$ studies.

4. **The $^{7}Li(p,\alpha)\alpha$ Reaction**
   Time-of-flight techniques were used in a unique way to measure the energetic alphas from this reaction. From the time-of-flight data the Q value of the reaction was determined.

There is presently great interest and excitement over the newly found use of accelerators for trace-element analysis. The beam of charged particles from the accelerator is targeted at the material to be analyzed, whose constituents are then identified by the characteristic X-ray emissions from the sample. This method of non-destructive analysis has great sensitivity, being able to detect elements present in masses as low as 10^{-12} grams. To further its research capabilities in this area, the Special Training Division will outfit a newly acquired 2MeV accelerator as a trace element analysis facility using charged-particle-induced X-ray fluorescence.

In addition to this research with low-energy (up to 5 MeV accelerators), the staff also conducts collaborative research using higher energy accelerators at Oak Ridge National Laboratory and the University of Georgeia. In recent experiments, light target nuclei such as boron, carbon, and beryllium have been bombarded with ^{3}He particles 1) to investigate the correspondence between the Distorted Wave Born Approximation Theory and experimental data, and 2) to establish a systematic set of optical potentials as a function of energy and mass number. Reports of these research projects are made periodically in the literature. A complete bibliography of recent work is available on request.

Administration and Support

The medical research program is carried out in ORAU by the Medical Division under the direction of its chairman, G. A. Andrews, and its associate chairman, R. M. Kniseley. It is chiefly supported by the Division of Biology and Medicine of the Atomic Energy Commission, under the direction of John R. Totter. A number of studies of the clinical effects of low doses of radiation and the low-exposure-rate facility are supported by the National Aeronautics and Space Administration through an interagency agreement between NASA and the Atomic Energy Commission. The work on infections in patients following irradiation is supported by the Department of the Army, through an interagency agreement between the Department of Defense and the Atomic Energy Commission. The marmoset project, with immunological studies of the genetically different types of blood-forming cells which characterize this animal, is supported by a grant from the Arthritis and Metabolic Diseases Institute of the National Institutes of Health. The lipid research project has grant support from the American Cancer Society, the National Institutes of Health, and the National Multiple Sclerosis Society, supplementing AEC funds. The cytogenetics program to investigate the chromosome breakage in women taking oral contraceptives and the study of the concentration of gallium by malignant tissue are supported by the National Institutes of Health. The Center for Information on Internal Dosimetry of Radiopharmaceuticals has support from the Food and Drug Administration through an interagency agreement between FDA and AEC.

PUBLIC EDUCATION

On behalf of the Atomic Energy Commission, ORAU conducts a nationwide educational program on the atom and its peaceful applications, involving operation of both the American Museum of Atomic Energy in Oak Ridge and traveling science-teaching exhibits that each year reach four to five million persons in schools and museums throughout the United States.

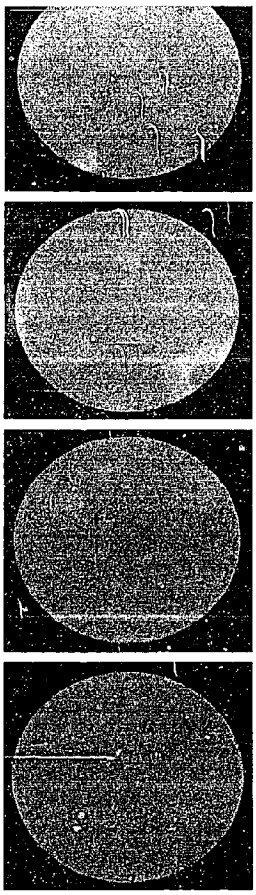
American Museum of Atomic Energy

During the year ending June 30, 1971, attendance at the American Museum of Atomic Energy totaled 131,252 visitors, down from the record 170,269 established last year, when nearly 30,000 persons attended special showings of Apollo 11 and 12 moon rocks and Oak Ridge-designed equipment for the lunar-landing mission. Other than the absence of an attraction comparable to the public showing of moon material, the major factors in the attendance decline were reductions in staff that limited the number of visiting groups that could be scheduled for tours and the elimination or curtailment, for budgetary reasons, of many normal promotional activities. In spite of these limitations, however, the year's attendance included more than 400 school groups and foreign visitors from 100 countries.

A significant development this year was the establishment of a corps of volunteers whose services in support of the professional staff have made it possible to continue "live" teaching as an integral part of the Museum program and have focused more attention on community involvement.

By arrangement with the Mayor's Science Museum Development Committee and the cooperative efforts of interested citizens of Oak Ridge, more than 90 volunteers were trained and scheduled to handle the basic duties of receptionist in welcoming visitors to Oak Ridge and the Museum. The work of the volunteer receptionists, by freeing regular Museum staff from these duties, increased the number of conducted tours that could be given.

The cooperative ORAU—Oak Ridge National Laboratory Student Educational Tour program on Saturdays was continued. This program, available to students in the ninth grade and above, consists of a 90-minute Museum tour followed by visits to the Graphite Reactor and other facilities at ORNL.



In addition to its regular public programs and special showings, the Museum serves as the base of operation for the extensive AEC traveling educational program that includes the "This Atomic World" high school lecture-demonstrations, circulating museum exhibits, and the development, testing, and fabrication of exhibits and exhibit components.

The Museum also recruits and trains nuclear-information personnel to serve as teacher-demonstrators with these traveling programs. New teacher-demonstrators participate in an intensive nine-week course on the basic principles of atomic energy, with many of the lectures for this course presented by ORNL staff.

Another feature of the program has been the introduction of a weekly series of lectures for summer visitors to Oak Ridge. Begun in 1969 and continued during the past two summers, these sessions afford student and faculty research participants and other visitors an opportunity to hear of developments in Oak Ridge research outside their own areas of special interest.

"This Atomic World" Secondary School Lecture-Demonstration Program

The number of "This Atomic World" high-school units operated in partnership with state organizations has continued to grow, from one in 1966-67 to four in 1967-68, 10 in 1968-69, 17 in 1969-70, and 18 during the 1970-71 school year. There will be 19 jointly sponsored units in operation in 1971-72, with three new sponsoring institutions—University of Tennessee, University of California at Los Angeles, and the Pacific Science Center, Seattle—joining the following sponsors who have renewed their contracts with ORAU: University of Alabama, University of Arkansas, Lawrence Hall of Science (Berkeley, California), University of South Florida, Northern Illinois University, Louisiana State Board of Nuclear Energy, Michigan State University (two units), Empire State Atomic Development Associates, Inc., North Carolina State University, Pennsylvania State University, Geneva College (Pennsylvania/Ohio), Oklahoma State University, Texas A & M University, Virginia Polytechnic Institute and State University, and University of Wisconsin.

In addition, 35 utility companies are financially involved in the support of this cooperative program. ORAU itself operated two units in 1970-71 and will operate one unit directly from Oak Ridge in the coming year.

Under cooperative agreements for the high-school program, the sponsoring organization hires and pays the teacher-demonstrator, schedules schools to be visited, prepares additional program material if desired (up to 25 percent of the program), and provides for vehicle operation and maintenance.

In June, when all of the "This Atomic World" lecture-demonstration schedules for 1970-71 were completed, the 20 units had logged more than 334,762 miles, visited 2,612 schools, and reached 1,901,848 secondary-school students.

Special programs also were presented for 224 groups totaling 26,517 persons. Sponsors of special programs included power companies, colleges and universities, educational conferences and institutes, civic, church, and 4-H clubs, scout groups, museums, and other organizations. A special series of modified "This Atomic World" programs was given during the summer of 1970 in New York City at community and recreation centers, summer schools, and the New York Hall of Science. These programs were arranged in cooperation with the Empire State Atomic Development Associates, Inc., and scheduled through the New York Hall of Science.

"This Atomic World" teacher-demonstrators begin their assignments with nine-week summer training program at the American Museum of Atomic Energy and then return to Oak Ridge for periodic briefings on latest developments in atomic research and applications.

ORAU trains the teacher-demonstrator in Oak Ridge during the regular nine-week summer session for its own new teacher-demonstrators, provides the demonstration equipment and vehicle, and supervises and evaluates the program in field operation. Some of the sponsoring utility companies employ public-information personnel who are concerned with production of nuclear power, and these men may be trained along with the teacher-demonstrators assigned to "This Atomic World" units.

Circulating Museum Exhibits

The "Energy Laboratory," newest of the large touring museum exhibits operated by ORAU for the AEC, remained at the Pacific Science Center, Seattle, during the entire year and had an attendance of 307,637 visitors.

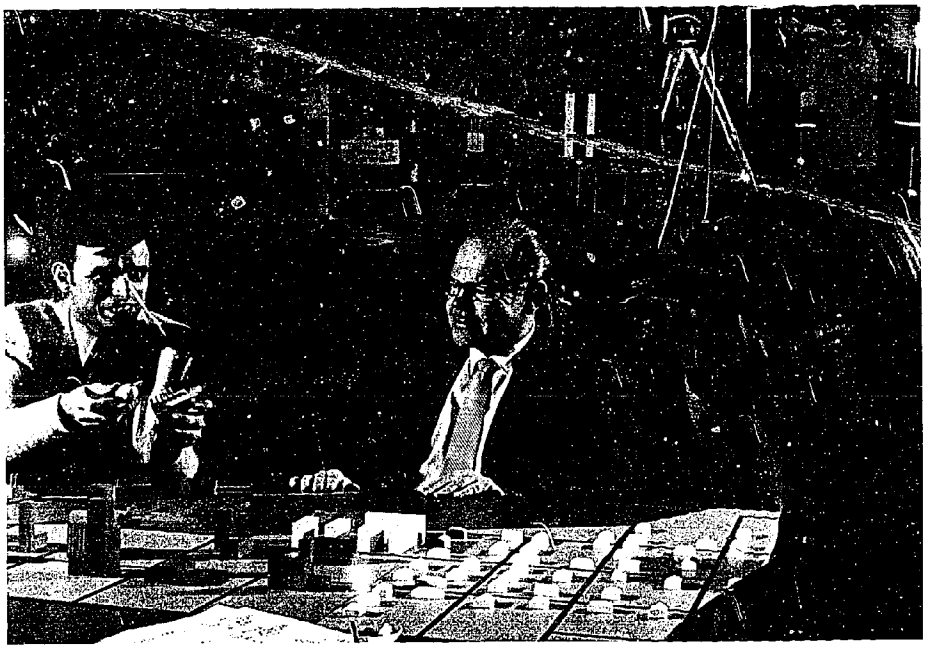
The "Life Science Radiation Laboratory," a working laboratory for museums, features live demonstrations on the use of radiation in biology, agriculture, and medicine.

This exhibit, combining a graphic display of the story of energy with regular lecture-demonstrations by a specially trained teacher-demonstrator, is designed for extended showings at large museums throughout the country. The teacher-demonstrator trains members of the sponsoring museum's staff as demonstration assistants for the presentation.

The basic structure of the "Energy Laboratory" is a ring-shaped enclosure, 20 feet in diameter and 8 feet high. The exterior wall is a diorama of pictures and three-dimensional representations that outline the story of energy, from the creation of the universe, through man's discovery of fire, the development of mechanics, and the Industrial Revolution, to the harnessing of the power of the atom's nucleus.

One segment of the circle is the lecture-demonstration area, where the teacher-demonstrator presents a "live" in-depth explanation of the energy story. In the course of the lecture, he uses a variety of demonstration materials, motion pictures, and slides to illustrate the growth of man's dependence on new and expanding sources of energy.

While the exhibit was at the Pacific Science Center, the teacher-demonstrator conducted 25 workshops on basic nuclear science for teachers and for Boy Scouts, the latter to enable them to earn the Atomic Energy Merit Badge. A special 10-day "Environmental Teach-In" was organized and conducted in cooperation with the exhibit, with speakers from the Seattle area covering various environmental issues.



A classroom game called Unicity was developed as part of the "Science In Your Life" public understanding program for high schools. The game-board layout gives students experience in exercising choices on the location of power-plant and industrial developments within an urban complex and in planning for transportation, housing, and recreational needs.

The "Life Science Radiation Laboratory," a portable demonstration laboratory-in-the-round, allows spectators to observe radiation effects in live fish and small animals, growing plants, and microorganisms (under a microscope attached to a closed-circuit television camera). Early in the year the exhibit was refurbished in Oak Ridge, then moved to the Center of Science and Industry in Columbus, Ohio, where it remained through the entire academic year. Total attendance was 166,830.

"Radiation and Man," now an unmanned exhibit, remained at the Pacific Science Center in Seattle where it is maintained by the staff of the Center. It had 245,989 visitors during the year.

"Science In Your Life" Public Understanding Program

Under a grant from the National Science Foundation, a new high school lecture-demonstration, "Science In Your Life," was developed and operated during the last three months of the 1970-71 school year. Designed especially for presentation to high-school students who are not science majors, this experimental program, supported by the Foundation's Public Understanding of Science Office, stressed the impact of contemporary science and technology on the nation's overall social and cultural development. During each school visit, the teacher-demonstrator manning the unit gave an assembly presentation for the student body and then met individually with classes in the humanities and social sciences during the remainder of the day.

As in the "This Atomic World" high-school program after which it was patterned, emphasis was on "live" demonstration of science phenomena and direct participation of students, using special instructional devices and animated displays both on stage and in the classroom. The teacher-demonstrator also scheduled workshops for teachers in fields outside the sciences, to assist those in history, for example, in the treatment of material on the history of science within their courses.

Subject matter was chosen to emphasize the interrelations between science as a human process for seeking new knowledge and the application of that knowledge for social ends, with particular attention to the crucial role of society in determining how new knowledge is used, whether to create or to solve problems.

Recycling of waste, rapid transit, society's energy demands, magnetohydrodynamics, and environmental problems were among the topics discussed. The program was presented at 25 secondary schools in East Tennessee, at eight schools in Georgia, and at the Buhl Planetarium in Pittsburgh during its experimental phase. The American Institute of Research is participating under a subcontract in the evaluation of "Science In Your Life" as a public understanding program.

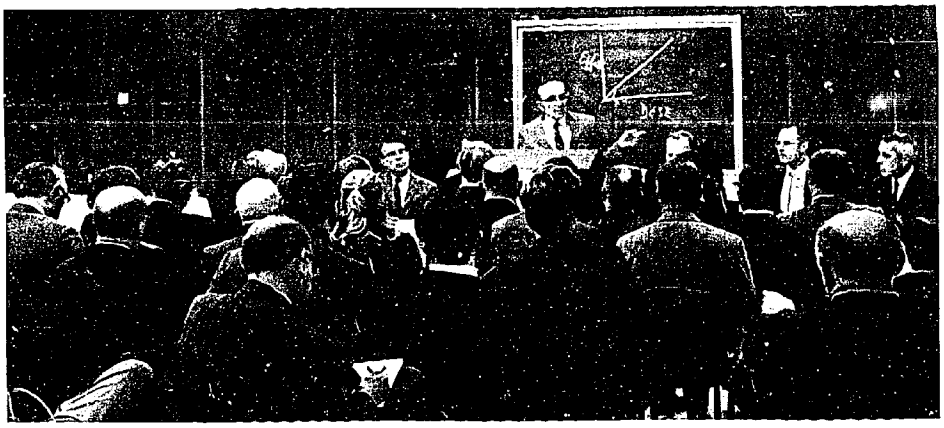
Workshops on Nuclear Power and the Environment

Public concern with the quality of the environment today extends to every facet of electric power generation by nuclear or conventional means—from national policy on energy resources to plant siting and specific questions of public health and safety and environmental impact. In response to this growing concern, two workshops were conducted on Nuclear Power and the Environment for interested citizens and for management and information personnel of electric utilities.

In November 1970, ORAU planned and conducted a series of 14 workshops and seven civic-club lectures on the basics of radiation and reactors for 580 citizens and community leaders in Midland, Michigan. These presentations followed an Oak Ridge visit by 50 Midland civic leaders for a special briefing on nuclear power plants and their ecological, environmental, and economic effects on the communities in which they are operated. The subsequent program in Midland over a two-week period was carried out at the request of the Midland Nuclear Power Committee, a citizens' group concerned with the nuclear reactor proposal of the Consumers Power Company and Dow Chemical. The group's chairman, Dr. Wayne North, a Methodist minister, had attended the ORAU "Science for Clergymen" conference in the summer of 1969.

In May, a three-day workshop was offered in Oak Ridge for 20 electric utility management and information personnel to prepare them to discuss nuclear power and the environment in a way that would be responsive to questions of the public. The objectives were 1) to provide a factual background on the basis of which they could speak knowledgeably to the public regarding the environmental aspects of electric power growth and 2) to enable participants to respond substantively and with understanding to the most frequently asked questions in this subject field. Lectures, panel discussions, and

laboratory exercises covered basic principles of atomic energy and reactor operation and, more specifically, reactor safety, thermal effects, radiation standards, and radioactive waste disposal. In addition to ORAU staff members, lectures were given by Oak Ridge National Laboratory and AEC scientific personnel.



Fifty community leaders from Midland, Michigan, proposed site of a new nuclear power plant, visited Oak Ridge in November for briefing by ORAU and Oak Ridge National Laboratory staff on the basics of radiation and reactors and their environmental effects.

In May, ORAU began a series of workshops on "Nuclear Power and the Environment" for electric utility and nuclear industry representatives who are called upon as public spokesmen on this topic.

Environmental Experiments for High Schools

Under another National Science Foundation grant, ORAU this year began development and testing of a "do-it-yourself" package of environmental experiments for the high school science curriculum. Under the pilot program, to be carried out in selected high schools nationally during the next year, students will build environmental measuring devices from basic electronic components and then use them to monitor air, water, noise, and radiation pollution levels in their home communities. The package of instruments, with accompanying guides for experiments in which they will be used, is designed to increase student awareness of the complexity of environmental problems and to stimulate interest in their solution through first-hand experience in environmental monitoring and measurement.

The multiple-instrument kit consists of a basic read-out meter that accommodates four different probes—to measure water conductivity, air particulate content, noise level, and radiation. These electronic instruments will be supplemented in the package of experiments by low-cost chemical indicators and simple sample-collection devices.

The aim of the program is to provide educators with tested materials for use in upgrading environmental education at the secondary-school level and, in turn, to encourage young people to consider careers in environmental research and related technologies.

Results will be reviewed by curriculum developers and laboratory-equipment manufacturers and published, together with complete plans, blueprints, and laboratory guides for the experimental equipment, in science education journals, to make this information more widely available among secondary teachers.

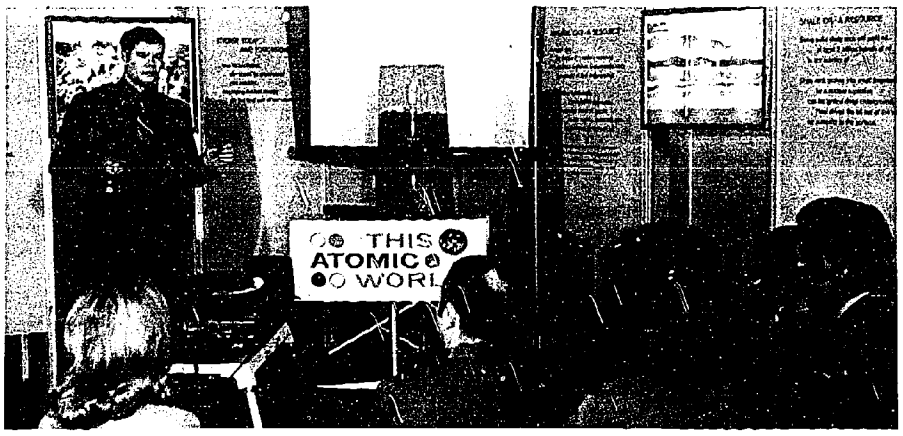
During the 1971-72 school year, ORAU will distribute 25 of the environmental experiments packages to high schools through the "This Atomic World" lecture-demonstration, operated nationwide for the U. S. Atomic Energy Commission. Schools participating in this initial test will be chosen from among the nearly 3,000 visited by this program each year.

Special Programs In Western States

"Your Stake In The Atom," housed in a portable geodesic "Exhibidome," was updated and refurbished for use in the initial stage of an educational program for the AEC's Division of Peaceful Nuclear Explosives, administered through its Nevada Operations Office. Many of the exhibits were repainted, copy was revised, a miniature mural was designed and produced, and many black-and-white photographs were replaced by color photos. The exhibit was viewed by 149,980 people while on display at nine state fairs in Wyoming, Colorado, Utah, Nevada, and Arizona during the summer and fall of 1970.

As a followup to this program, a new multi-mode exhibit, "Energy Today and Tomorrow/This Atomic World," was designed, fabricated, and then operated in the same area from February through May with financial support from the Atomic Industrial Forum. The exhibit was transported in its own specially equipped van, which accommodates a full set of "This Atomic World" high-school-program equipment as well as special demonstration material on the AEC's Plowshare program to develop practical applications of nuclear explosives in science and industry.

The "This Atomic World" portion was presented to 24,000 high school students and adults in 33 secondary schools in Colorado, Utah, and Wyoming. During this period, "Energy Today and Tomorrow," consisting of light-weight interchangeable panels with illuminated transparencies, was set up for periods of up to two weeks at the following Colorado locations: McClelland Public Library, Pueblo; Penrose Public Library, Colorado Springs; Denver Public Library; Moffat County Museum, Craig; and City Hall, Grand Junction.



New "Energy Today and Tomorrow" exhibit, operated by ORAU with support from the Atomic Industrial Forum, combines "This Atomic World" high school presentation with demonstration material on AEC Plowshare Program to develop practical applications of nuclear explosives.

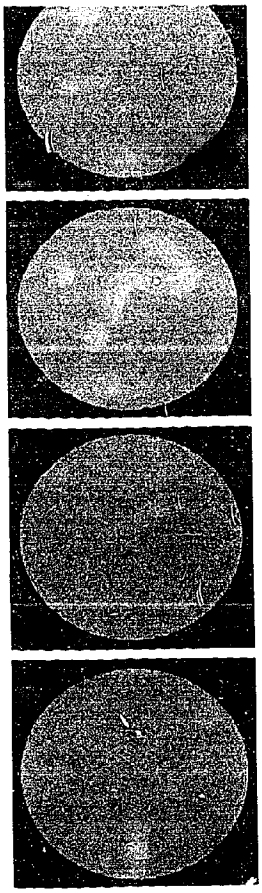
Association of Science-Technology Educational Centers

Directors of 17 major science museums in all parts of the U. S. met at the American Museum of Atomic Energy in April to discuss their mutual interests in the development of museum-based programs to increase public understanding of science and technology. The meeting led to the formal organization of a new Association of Science-Technology Educational Centers, which will provide a means for more effective interchange of information among science museums and for exploration of possible new cooperative programs. Courtland S. Randall, of ORAU, was elected vice chairman of the Association.

Administration and Support

The operation of the American Museum of Atomic Energy and the traveling public education program, together with exhibit design and construction, is carried out by the Information and Exhibits Division of ORAU, of which Courtland S. Randall is chairman and Frederick P. Napp assistant chairman. These programs are supported by the Division of Technical Information of the Atomic Energy Commission, whose director is Edward J. Brunenkant. Additional work for other AEC divisions and for outside organizations accounted for approximately 16 percent of the division's activities during the year. Particular attention has been given to the growing need for public education on the environment. To this end, the division has presented proposals for such programs to various federal gencies and is participating in the ORNL-NSF study project on "The Environment and Technological Assessment."

TRAINING AND TECHNOLOGY



Training and Technology (TAT) was established by ORAU in 1966 as an experimental manpower project to train unemployed and underemployed persons in job skills critically needed by modern, technology-based industry. In its third year, TAT began the transition from a largely experimental program to one combining experimental activities with regular training operations. Funding shifted from that provided solely until then by the U.S. Departments of Labor and Health, Education, and Welfare under the federal Manpower Development and Training Act, to a diversified pattern of participation that included substantial financial support by other federal as well as state and local agencies. Under these new arrangements, the target group for training became persons who are "disadvantaged," as defined by Department of Labor criteria, as well as being unemployed or underemployed.

During the past two years, TAT has further expanded its base of financial support and the geographic area from which its trainees are drawn. And beginning in October 1971, according to a proposal currently under review, TAT will again make a transition—this time to become an Industrial Training Center for Atomic Energy Commission contractors in the eastern U.S.; a second industrial center utilizing AEC facilities is under study for the western U.S. Thirty major AEC contractors will be able to utilize the two facilities. TAT to date has trained more than 500 employees for nine different AEC contractors in six states, with excellent performance and retention records.

In addition to training and upgrading up to 200 AEC employees, in the first year the new Industrial Training Center in Oak Ridge will train approximately 200 veterans who will receive GI benefits. Additional sponsors, including federally sponsored local-area Concentrated Employment (CEP) and Work Incentive (WIN) programs, which currently participate in TAT, will increase the number of those trained to more than 400 per year.

After five years of operation, TAT has gained recognition in the field of manpower development for its demonstration that standards of high industrial quality can be maintained in a comprehensive program that takes into account the special services required for disadvantaged persons. It has demonstrated that disadvantaged persons with at least a sixth-grade functional academic level can successfully complete training in six months and be placed in entry level industrial occupations.

Operating under the single program title, Training and Technology, are two separately financed but interrelated and interacting components:

(1) the Worker Training program, which over a five-year period will have graduated approximately 1,575 trainees and placed them in high-skill industrial jobs, and

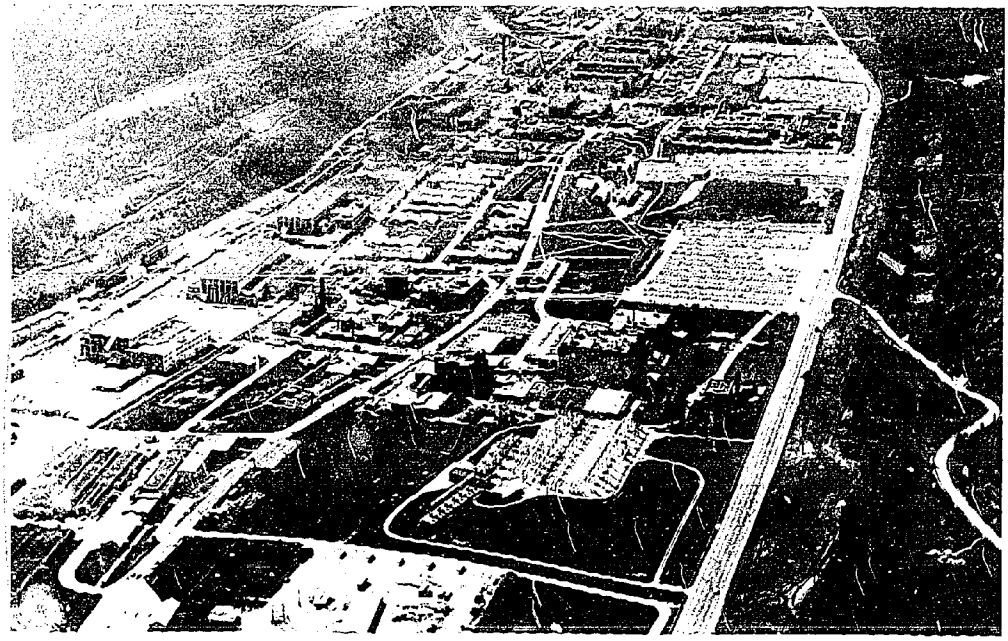
(2) Experimentation, Demonstration and Utilization, which is concerned with innovative approaches to manpower development involving new combinations of industrial, educational, and governmental training resources, with assessment and evaluation of these new approaches, and with documentation of the TAT experience and its dissemination to other interested manpower agencies.

A third component of TAT, the Teacher Institute, provided pre-service and in-service training for vocational-technical teachers. In the fall of 1970, funding for the Teacher Institute was discontinued by the Office of Education. However, the program has been continued with modifications under a cooperative arrangement between the University of Tennessee and the Nuclear Division, Union Carbide Corporation, which together had operated the Teacher Institute since 1968.

Worker Training

TAT worker training is conducted at the Atomic Energy Commission's Oak Ridge Y-12 Plant with support from the U.S. Departments of Labor and Health, Education, and Welfare, Atomic Energy Commission, Appalachian Regional Commission (Tennessee, Kentucky, Virginia, West Virginia), Concentrated Employment Program (Chattanooga and Nashville), Work Incentive Program (Tennessee and West Virginia), West Virginia Employment Service, Tennessee Vocational Rehabilitation, and the State of Illinois/Standard Oil of Indiana.

As these diverse sources of support indicate, trainees are recruited from a wide range of geographic locations and cultural backgrounds. At least 75 percent are disadvantaged and 40 percent are black or members of other minority groups. Sponsoring organizations cooperate with appropriate state Employment Service offices; TAT staff assist in the recruitment and selection process.



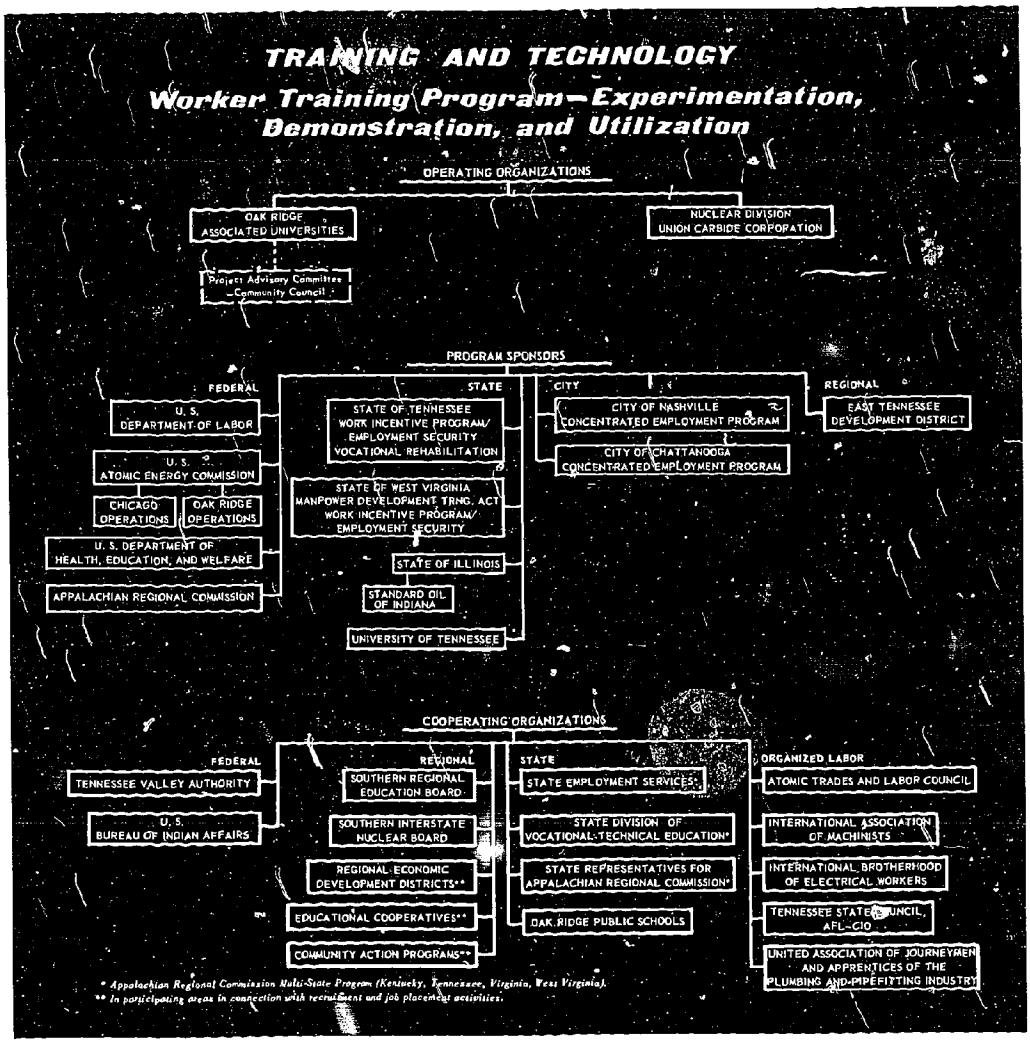
The TAT worker-training program is conducted at the U.S. Atomic Energy Commission's Oak Ridge Y-12 Plant, operated for the AEC by the Nuclear Division, Union Carbide Corporation. One of the AEC's most versatile facilities, the Y-12 Plant supports such activities as process development, heavy engineering, and specialized production, including fabrication of nuclear weapons components.

ORAU and the Nuclear Division, Union Carbide Corporation, AEC prime contractor for the operation of the major production and research facilities in Oak Ridge, are the principal operating partners in TAT, together with the Tennessee Department of Employment Security. ORAU is responsible for project coordination; program development, experimentation, and assessment; trade-related instruction in math and science; counseling and supportive services; and reporting to sponsors and others with manpower interests. Carbide supervisors and skilled craftsmen provide classroom, shop, and laboratory instruction in the following major training areas: Technician Section—drafting, electronics, physical testing, and chemistry; Machining-Inspection Section; and Mechanical Trades Section—mechanical and process operation and welding.

In 1970, the Worker Training program graduated 328 trainees into entry-level industrial jobs with employers across the nation. More than 94 percent of the available graduates

were placed in jobs averaging $3.09 per hour. The average wage of 1970 graduates prior to entry into TAT was $1,061 per year, and beginning wages after leaving the program averaged $6,427 per year. Graduates have been employed in more than 170 different industrial occupations related to their training; their employers, besides Union Carbide in Oak Ridge, include such advanced high-technology corporations as U.S. Steel, AVCO, Chicago Bridge and Iron, Pittsburgh-Des Moines Steel, Lockheed, Bethlehem Steel, DuPont, and Ingalls Shipbuilding.

In addition to receiving skilled and technical training and related instruction, TAT graduates are prepared in "industrial behavior"—attendance, safety, communication, test-taking, job application, employer interviews, and job selection. A General Education



Development (GED) program is offered to help trainees who do not have a high school diploma increase their employment potential. Of 86 graduates in 1970 who did not have a high school diploma, 55 earned their GED equivalency diploma while at TAT.

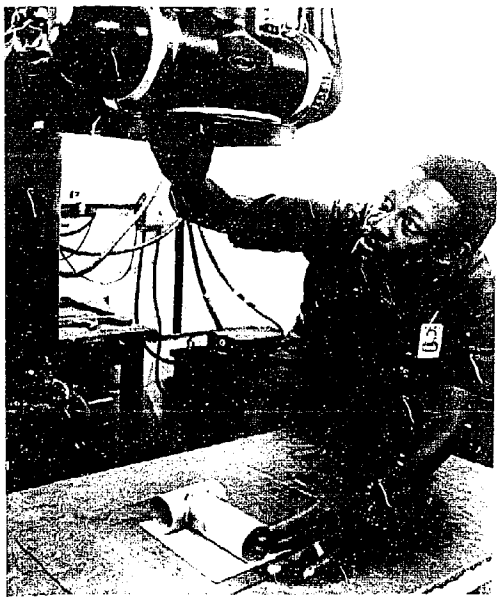
Worker Training currently graduates about 330 trainees per year. The average enrollment is 180 and trainees stay in the program until their Union Carbide training supervisors certify that they have reached entry-level jobs status within their chosen training area. Training time averages six months, although some trainees are job ready after as little as three or four months.

The typical TAT trainee is poor, unskilled, unemployed or employed in a dead-end job, and between the ages of 18 and 25. The current class includes 11 blacks from the Chicago area who will be employed in Standard Oil's Naperville, Illinois, research facility; 17 urban blacks from Chattanooga and Nashville; 45 white rural Appalachians, mostly from Tennessee; approximately 15 welfare recipients from Virginia and Tennessee; and an additional 75 Tennesseans from a variety of cultural backgrounds. Forty-two percent of the class are black and 82 percent "disadvantaged"—meaning that they are poor and either (1) a school dropout, (2) a member of a minority, (3) under 22 or over 45 years of age, or (4) handicapped.

Experimentation, Demonstration, and Utilization

The Experimentation, Demonstration, and Utilization component of TAT encompasses varied but related activities whose common goal is twofold: (1) to assess, refine, and improve the existing program through flexible, experimental approaches, and (2) to influence the establishment and improvement of manpower training programs through documentation and dissemination of TAT experience.

TAT encourages the participation of university staff and students in experimental studies and internships. Seventeen master's degree theses have been based on TAT data, along with several smaller-scale studies. During 1970, two interns from the University of Tennessee School of Social Work served six months in guidance and counseling and supportive services.



Since 1966 TAT has prepared more than 1,500 graduates to the entry level for employment in modern, high-technology industry. Nondestructive testing of materials by x-ray and other methods is one of six occupational areas in which training is offered.

To carry out experimentation, demonstration, and utilization objectives, staff members work with industry and wit other manpower agencies to assess and seek new applications of the TAT experience.

A symposium, University Participation in Experimentation and Manpower Training, was attended in April by representatives from a wide variety of educational institutions and disciplines. Sponsored by TAT and the University of Tennessee's Industrial Management Department, the symposium encouraged participants to utilize TAT as a manpower experimentation laboratory.

In another TAT demonstration activity, 75 manpower officials from across the state and nation attended a March workshop on Planning Manpower Strategies, co-sponsored by the Tennessee State Comprehensive Area Manpower Planning System (CAMPS)

Committee, TAT, and the Tennessee Valley Authority. Its purpose was to provide a training exercise for participants in determining an area's manpower resources, needs, and priorities and in utilizing available resources to meet these needs through innovative programs. The officials assumed community roles in pre-arranged manpower problems which required strategic planning.

Through experimental approaches to the training process, the program is continually assessed and refined. A TAT experimental work sample, currently being validated, is a potential selection device for TAT and other industrial manpower training programs. The work sample, employing a tool box, a laboratory kit, and a time-punch clock, will offer prospective trainees an opportunity to demonstrate aptitudes for many industrial skills. The work sample, which received top ranking from a review board at Auburn University, may also be used as a guide in the placement of trainees into specific training areas.

Another experimental pilot program, begun early in 1971 by Union Carbide, will assist 30 employees at lower grade levels to attain their GED equivalency diploma and to improve their opportunities for advancement. An additional 15 Carbide employees, including some higher co and supervisory personnel, have joined the program and TAT has submitted a proposal for an in-depth study to analyze current upgrading practices in Oak Ridge industrial plants, to determine and test alternative methods of upgrading, and to utilize proven methods in the U.S. Atomic Energy Commission contractor system.

Participation by the State of Illinois and Standard Oil of Indiana, which are jointly sponsoring 12 black chemical-technician trainees, has resulted in program modifications to meet special needs. A new curriculum was set up for these trainees utilizing laboratory facilities of the ORAU Special Training Division, technical and trade-related instruction and supportive services of TAT, and supervisory chemical technologists from the Oak Ridge Y-12 Plant. Senior personnel from Standard Oil's Naperville facility have also served "residencies" at TAT to equip themselves to offer future training programs in Standard Oil facilities.

One further new arrangement in the current program is the training of welfare recipients from West Virginia's Work Incentive (WIN) program with academic levels lower than TAT's general requirement of a sixth-grade functional level. Experience with this group has emphasized several special needs, such as prevocational training, intensive remedial and supportive services, technical training with lower occupational goals, and longer orientation periods. West Virginia's WIN counselor has been serving extended residencies at TAT to provide extra support and to gain training experience. TAT staff have been involved with West Virginia organizations to help establish prevocational programs in that state.

Thus, TAT stands as an example of how existing training resources and a wide variety of federal, state, and local agencies can interact to meet both manpower development needs and industry's demand for skilled employees. To encourage utilization of TAT experience, manpower development services, such as technical assistance in establishing and administering a training program, are available to interested organizations.

As part of the effort to disseminate information, reports published in the past year include:

(1) The General Education Development (GED) Program at TAT (August 1970), which describes the program to assist high school dropouts obtain an equivalency diploma.

(2) Preparing Rural Appalachians for Skilled and Technical Jobs: A Regional Approach (March 1971), which covers Appalachian Regional Commission participation in training and program development from October 1969-September 1970.

(3) University Resources and Industrial Manpower Development (April 1971), which describes how resources of various educational institutions (particularly the University of Tennessee) have been utilized in TAT.

(4) TAT 1970 Annual Report (March 1971), covering Experimentation, Demonstration, and Utilization activities during 1970 and the 1969-70 Worker Training program.

The Teacher Institute

The Teacher Institute, administered from 1966 to 1968 by ORAU and since by Union Carbide and the University of Tennessee, has included in its functions in-service training of vocational teachers, preservice training of prospective vocational teachers, and preparation of candidates for the master's degree in industrial education.

The university-industry partnership has been successful in (1) contributing to the teachers' understanding of the disadvantaged through constant contact and sharing of facilities; (2) providing microteaching opportunities; (3) developing proficiency examinations in technical areas for university credit; (4) providing special problems for individual study at the industrial installation; (5) offering developmental instruction whereby the teacher can obtain remedial aid as needed; and (6) offering accelerated courses for the exceptionally bright or experienced teacher.

Although funding for the Teacher Institute was discontinued by the Office of Education in the fall of 1970, industrial education courses, funded by student fees, continue to be offered at the TAT site after working hours. Seventy-five persons are currently enrolled; 55 are Union Carbide craftsmen and technicians and 20 are local teachers.

TAT and the Community

A TAT Community Council was established in October 1970, with 17 members representing a wide range of Oak Ridge civic, educational, industrial, and government organizations. Its purpose is to further mutual understanding between the community and TAT and to provide trainees with an effective link to Oak Ridge's many resources. The council concerns itself with such efforts as facilitating recreational programs, improving the trainees' temporary housing, and serving as a TAT information source for community groups.

The Oak Ridge community became even more directly involved in the worker-training program in April 1971 when a Volunteer Corps was established. The volunteers, who are carefully screened and oriented, serve in many supportive capacities. They assist in trainee orientation to the community, lead tours of interesting area attractions, assist in interviewing and preliminary counseling, and tutor in trade-related and remedial subjects. The most important role of the volunteer is to welcome the trainee, who may be away from home for the first time, not only to TAT but also to the Oak Ridge community.

Through their own Trainee Council and Activities Council, participants work with staff to help meet needs of fellow trainees during their six-month temporary residence in Oak Ridge and to plan recreational and social activities.

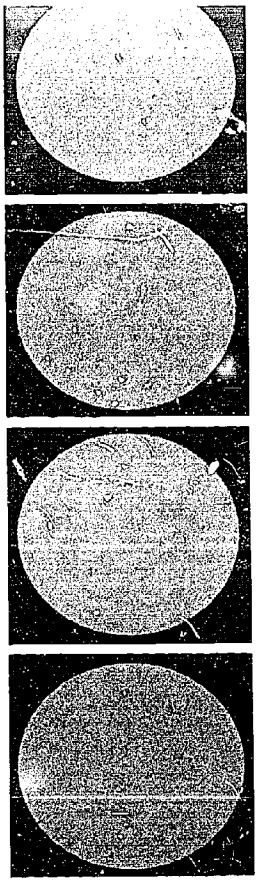
During the last training year, three Appalachian-area trainees have received Youth Fellowships under a program that provides opportunities for Appalachian young people to develop their leadership skills through special service-learning projects while in school or in training. Under the fellowships, the trainees have organized a program to assist their fellow trainees in finding part-time jobs during their six-month temporary residence in Oak Ridge. The fellowships, sponsored by the Appalachian Regional Commission under a program administered by the East Tennessee Development District, were the first awarded to young people other than college students. TAT's involvement in this program serves as a means of developing youth leaders from the industrial work force and as a complement to the traditional focus of these programs on college youth.

Administration and Support

TAT, since its inception in 1966, has been under the direction of Wendell H. Russell. TAT is attached to the Executive Office, under the supervision of the Assistant Director for Administration, Paul M. Elza.

Funding for the 1970-71 Worker Training program was provided by the U.S. Departments of Labor and Health, Education, and Welfare; U.S. Atomic Energy Commission; Appalachian Regional Commission; two Concentrated Employment Programs (Chattanooga and Nashville); two Work Incentive Programs (Tennessee and West Virginia); West Virginia Employment Service; Tennessee Vocational Rehabilitiation; and State of Illinois/Standard Oil of Indiana. TAT Experimentation, Demonstration, and Utilization is separately funded by the Department of Labor. The AEC provides facilities and equipment for the project at no cost.

BUDGET AND ORGANIZATION



The great number and diversity of programs conducted by ORAU under its contract with the Atomic Energy Commission and on behalf of the AEC and other governmental and private organizations is evident from the foregoing descriptions of their nature, objectives, and accomplishments during the past year. This diversity, which encompasses activities in education, information, research, and human resource development, is reflected in a corresponding complexity in sources of support and funding arrangements. A cost and budget summary for all programs, including funding sources and levels of support for this year and the previous year and projections for the year ahead, is provided in the table on the two following pages.

To carry out legal and fiscal obligations and to provide services to operating units in support of these varied activities, ORAU maintains a central administrative and service organization. The Executive Office and the administrative and service units form a basic management capability for planning, organizing, staffing, budgeting, directing, coordinating, and servicing a variety of programs. These departments operate under the direction of Paul M. Elza, assistant director for administration.

The Fiscal Services Department, under J. W. Rose, Jr., is responsible for accounting, payroll, budget preparation and control, and the general financial arrangements of the corporation, and for contract compliance and execution. This department's functions also include administration of the supply office under Harrison E. Elliott, which handles purchasing and supply warehousing, and supervision of the Data Processing group, whose services are available to all program and administrative units.

The Technical Services Department, under T. W. Martin, is responsible for all construction projects and engineering services; for building, equipment, and grounds maintenance; and for the central ORAU instrument, cabinet, and electronics shops. It also administers the general safety program of the Association. Accomplishments of the department during the year included the design and start of construction on an emergency power system for the Medical Division; installation of a sterile, water-filtration system for the division's laminar-flow, ultraclean patient-care facility; and construction of a cage washroom for one of that unit's animal colonies. Under the safety program, there were no lost-time accidents by Association staff during the year.

The Office of General Services, under Donald S. Hurtubise, is responsible for planning, organizing, coordinating, and supervising the Personnel Services and Library Departments and the Administrative Services Section as well as for other general administrative functions. The Administrative Services Section of the office is responsible for mail service, auditing, office supplies, travel arrangements and reimbursement, vehicle

COST AND BUDGET SUMMARY—ALL PROGRAMS	Actual Costs FY 1970	Actual Costs FY 1971	Budget FY 1972
AEC Programs			
Medical Division	$2,044,900	$2,070,100	$1,985,000
University Programs Office*	2,013,900	1,482,600	995,000
Information and Exhibits Division	689,700	476,000	424,000
Special Training Division	629,100	450,400	480,000
Special Projects Office	120,900	54,900	40,000
Other Projects:			
DNET Reporting	31,100	27,400	20,000
UNISOR—AEC share			40,000*
Other	36,100	32,000	25,000
TOTAL AEC PROGRAMS	$5,565,700	$4,593,400	$4,009,000
AEC Programs—Funded by Others			
Resident Graduate Program	$ 78,700	$ 102,000	$ 68,000
Training and Technology Program			
Union Carbide Nuclear Division	25,200	36,000	9,000
National Accelerator Laboratory	13,700	5,400	
Argonne National Laboratory	6,100	29,600	
Union Carbide—Exhibit Fabrication	23,500		
Nevada Operations—Exhibit Fabrication	29,300	61,200	
Film Library		4,500	21,000
TOTAL AEC PROGRAMS—OTHER CONTRACTORS	$ 176,500	$ 238,700	$ 98,000
Non-AEC Programs (Interagency Agreements and Grants)			
Medical Division			
NASA—"Retrospective Study of Radiation Effects"	234,200	$ 196,700	$ 170,000
U.S. Army—"Infections in Irradiated Patients"	71,100	77,600	85,300
NRC—"Fluorodensimetry Studies of the Heart and Lung Function"	2,100	400	800
NICHD—"Chromosomal Breaks"	49,700	61,400	94,200
NMSS—"Lipids Research"		25,100	12,000
NIH—"Immunology of Hematopoietic Chimerism in Tamarins"	71,700	78,400	41,800
NIH—"Studies of the Morphogenesis and Pathogenicity of Candida Albicans"	8,700		
NIH—"Lipid Biosynthesis"	2,500	25,900	25,500
NIH—"Symposium on Radionuclides"	10,300	500	
ACS—"Lipids Research"	51,600	41,900	13,300
ACS—"Conference on Gallium-67"		5,300	
UNC—"Collaborative Research"	6,100	5,300	4,900
NIH—"Gallium Scanning"	5,600	61,000	52,900
NCI—"Studies of Gallium-67"		4,500	22,500
FDA—"Information Center—Pharmaceutical Dosimetry"		2,300	27,800

***Costs for several of the programs administered by the University Programs Office are shared between ORAU and the participating Atomic Energy Commission laboratory. In order to give a complete picture of the level of these programs, cost figures have been obtained for FY 1971 from the Savannah River Laboratory (SRL) and are shown below with ORAU costs.**

	ORAU	SRL	TOTAL
Faculty Research Participation	$ 87,353	$ 62,700	$150,053
Undergraduate Research Training	81,918	11,600	93,518
Laboratory Graduate Participation	132,077	9,900	141,977
TOTALS	$301,348	$ 84,200	$385,548

	Actual Costs FY 1970	FY 1971	Budget FY 1972
Special Training Division			
NSF—"Institutes"	51,700	1,000	51,000
NSF—"Mobile Isotope Lab"	71,700		
OE-UT—"Academic Year Institute"	70,100		
USPHS—"Autotutorial Course"		49,900	59,300
NSF—"Technical Physics Modules"		100	24,900
USOE—Fisk University "Academic Year Institute"		15,400	4,100
University Programs Office			
NSF—"Undergraduate Research Participants"	$ 10,200	$ 10,900	$ 8,500
Special Projects Office			
NSF—"Clergymen Conference"	10,000		
HEW—Knoxville College—"TNI"		30,900	10,300
NSF—"Tutorial Conference for Women"		19,900	1,200
Information and Exhibits Division			
NSF—"Science in Your Life"		29,300	7,200
NSF—"Environmental Experiments Program"		4,500	12,500
Executive Office			
DOL—"Worker Training"	68,800	78,800	25,100
DOL—"Experimentation-Demonstration"	218,500	219,000	292,800
OE—"Teacher Training"	8,800		
CEP—"Worker Training"	64,000	84,900	20,300
ARC—"Worker Training"	80,100	107,600	34,500
EOA—"Worker Training"	44,000	28,500	9,000
NIH—"Demographic Group Conference"		2,900	6,900
VA—"WBLS Conceptual Design"		1,300	
State Add Ons—"Worker Training"		28,300	34,300
TOTAL NON-AEC PROGRAMS	$1,211,500	$1,299,500	$1,152,900
ORAU Corporate Operations	$ 281,400	$ 220,000	$ 247,900
UNISOR—Universities share			31,400*
TOTAL ALL PROGRAMS	$7,235,100	$6,351,600	$5,539,200
Program Proposals Under Review			
Medical Division			
NIH—"Immunology of Aging in the Chimeric Marmoset"			$ 113,300
ACS—"Lipids Research"			45,800
NIH—"Medical Research" (Five proposals)			184,500
Special Training Division			
NSF—"Summer Institutes" (10 proposals)			271,200
NSF—"Summer Institute—Webb School"			113,900
DOL—"Building Allied Health Manpower Programs"			181,300
Executive Office			
Training and Technology Program			
DOL—"Upgrading in an Industrial Setting" (18 months)			177,000
DOL—DHEW—"Manpower Development for Industry"			792,000
TOTAL PROPOSALS UNDER REVIEW			$1,879,000
*Total UNISOR operating cost			$ 71,400

management, office equipment control and maintenance, property records, security clearances, and other such services.

The Personnel Services Department is responsible for recruitment, wage and salary administration, employee benefits, and employee relations. This year, employee records were placed on IBM unit-records equipment, group health insurance coverages were broadened into a comprehensive plan, and eligibility for participation in the Association's retirement plan was liberalized, with ORAU paying a larger portion of contributions. An additional paid holiday, bringing the yearly total to nine, was added for all employees.

The Library Department and Data Processing are among the special services which occasionally assume programmatic responsibility for special functions.

The Library Department, under J. Louise Markel, provides services to all ORAU divisions and offices as well as personnel of the Atomic Energy Commission and the Nuclear Division, Union Carbide Corporation, high school students, and the general public. The Library maintains a collection of more than 40,000 volumes, 100,000 technical reports, and 350 journal titles, with primary emphasis on the nuclear and radiation sciences and their biomedical applications.

The Data Processing group has direct programmatic responsibility for the collection and analysis of information on participants in Atomic Energy Commission educational programs on a nationwide basis and also provides data-processing services to other ORAU programs as required.

The Information Services Department, under Edward D. Aebischer, is responsible for the public information and publications activities of the Association, including ORAU press relations, editorial and graphic-arts services, printing and publishing, and reproduction and photographic services. The department also began operation this year of the AEC's Oak Ridge Film Library, one of 11 regional libraries that make loans of popular, technical, and historical films on atomic energy, free of charge. The Oak Ridge library serves a six-state area comprising Arkansas, Kansas, Kentucky, Louisiana, Mississippi, and Tennessee.

The Radiation and Chemical Safety Office, under James D. Berger, assists all divisions and departments in maintaining safe and healthful working conditions at ORAU. The staff assists in training employees in the safe use of chemicals and radioactive materials and is available to measure chemical concentrations and radiation levels with specialized monitoring equipment. The personnel radiation monitoring program and chemical and radioactive waste disposal programs are also administered by this office.

During the year covered by this report, no serious chemical or radiation accidents occurred. Airborne concentrations of chemicals were maintained within acceptable levels. Radiation exposures of employees remained well below the acceptable maximum level of 5000 millirem per year. The highest individual exposure was 310 millirem, and the average for all monitored employees was 91 millirem.

In support of ORAU divisional programs, the office continues to perform special radiation dosimetry, to design educational exhibits, and to lecture in training courses, as well as conducting its applied health physics and industrial hygiene functions.

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